CIVIL ENGINEERING

Published by the American Society of Civil Engineers

POWER HOUSE AND PENSTOCKS OF THE SERRA DO CUBATAO POWER DEVELOPMENT, NEAR SANTOS, BRAZIL
How the Flow of Rivers on the Far Side of the Serra Has Been Reversed to Supply This Plant Is Told in This Issue

Volume 8 — Number 8

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

AUGUST 1938

Among Our Writers

HENRY EARLE RIGGS, President of the Society, is an 1886 graduate of the University of Kansas. He has had a distinguished engineering career, including 14 years in the consulting firm of Riggs and Sherman and 18 years as active head of the department of civil engineering at the University of Michigan.

C. P. KAHLER had a background of varied engineering experience in railroad work when he became electrical engineer of the Oregon Short Line Railroad in 1912, with headquarters in Salt Lake City. In 1930 he was made system electrical engineer on the Union Pacific, with headquarters in Omaha, Nebr.

WILBUR M. WILSON after about 12 years of experience in the practice and teaching of engineering, joined the civil engineering faculty of the University of Illinois in 1913. In 1922 he assumed his present position of research professor of structural engineering. He is the author of numerous technical articles.

PORTER J. PRESTON left private engineering practice in 1915 to enter the U. S. Bureau of Reclamation. Today he directs one of the most comprehensive studies ever made by the Bureau, that of classifying all lands in the Colorado River basin. He has served on various government boards, studying operation and maintenance costs on both private and Government-operated projects.

A. W. K. BILLINGS has spent 36 years in charge of important public utility construction work in Cuba, Spain, Mexico, and Brazil. He was awarded the Navy Cross and Legion of Honor for distinguished service as engineer in charge of naval aviation construction abroad during the World War.

MARK SERRURIER has a B.S. from California Institute of Technology and an M.S. in structural engineering from the University of Illinois. Since 1932 he has been with the former school, making preliminary designs for the telescope and buildings, and in charge of the structural work on the telescope and dome building.

O. J. TODD was chief engineer of the China International Famine Commission 1923–1935, and through 1936 and 1937, consulting engineer to the Chinese Government and to the Shantung Government on Yellow River studies. Readers will recall his two previous articles on China in CIVIL ENGINEERING (June 1933 and August 1937).

EDWARD G. SEMON, after varied field and office experience, joined the staff of the General Electric Company, Schenectady, N.Y., in 1920. In 1924 he became structural engineer in the Construction Engineering Department, which position he still holds.

CONDE B. MCCULLOUGH graduated from Iowa State College in 1910. He was bridge engineer for the Oregon State Highway Department, 1919–1935; then with the U. S. Bureau of Public Roads on the Inter-American Highway in Central America. In 1937 he returned to Oregon as assistant state highway engineer.

JOSEPH B. TIFFANY, JR., is a graduate of the University of Illinois. After three years of surveying work he was transferred to the U. S. Waterways Experiment Station in April 1933. He has been in charge of numerous of the Station's model studies and general research projects, and is also editor of the Station's reports.

CHESTER H. GRAY has been a farmer all his life and associated with farm organizations for 30 years. He was a member of the Organization Committee that created the American Farm Bureau Federation; served on the Federation's legislative committee for 4 years, and as its Washington representative about 13 years.

F. W. PANHORST graduated from the University of Illinois in 1915. For 6 years he was resident bridge engineer for the Washington State Highway Department, and for the past 11 years he has been with the bridge department of the Division of Highways, State of California.

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Something to Think About

A Series of Reflective Comments Sponsored by the Committee on Publications

The Society as Leader of the Profession

Abstracted from 1938 Presidential Address, to Appear in "Transactions," Volume 103 (1938)

By HENRY EARLE RIGGS, PRESIDENT, AMERICAN SOCIETY OF CIVIL ENGINEERS
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THE long-continued depression in the United States has created many grave and serious problems, not only for individuals and for business firms and corporations but for social and professional organizations and groups. There has been disillusionment and despair for many and there is doubt and uncertainty as to the future in the minds of many others. The whole ugly picture compels analysis of conditions in the engineering profession. What must be done to keep up the morale and to help to eliminate the abuses which many engineers have experienced?

It is to the great engineering societies that the discouraged engineer naturally looks for help in his time of need. Can the American Society of Civil Engineers take the place of leadership when leadership is so much needed?

Significant Society Developments.~During the eighty-six years of the Society's existence it has changed its organic form and adjusted itself to meet the developing needs of the profession. The establishment of Local Sections, with the recognition of the San Francisco Section in 1905, was the fundamental change in organization which resulted in the Society's becoming a truly national body. The growth in the sixteen years following the establishment of the first Local Section was twice as much as that of the preceding fifty-three years.

The establishment of eight Student Chapters in 1920 and of thirty-one in 1921, followed by eighty more in succeeding years up to 1938, was a second radical change which had far-reaching results. The benefit to the Society of this early contact with thousands of young men each year cannot be questioned. The Student Chapters form a great reservoir from which the Society will draw the larger part of its membership in the years to come. In 1921 the Society had 458 Juniors, approximately $4^1/_2$ per cent of the total membership. On May 31, 1938, there was a Junior membership of 3,736, or 23.7 per cent of the membership on that date. This rapidly increasing number of Juniors creates a present problem but it also augurs well for the future of the Society.

A fundamental change in the Society organization came with the establishment of Technical Divisions in June 1922. The net result has been to turn a large part of the technical programs over to the Divisions, and, more recently, to put them in charge of research committees dealing with matters coming under their jurisdiction. In effect, to the Divisions has been given the direction of the important technical work of the Society.

How Can Local Sections Be of the Greatest Possible Benefit?~The legislative problems of the profession in any state can best be solved by the combined effort of the various engineering groups in the state. Not only must good legislation be supported, but that which is injurious to the profession of engineering must be opposed. The membership of any professional organization can be expected to increase only when the activity of the organization is pronouncedly along lines that are of distinct benefit to the profession.

When the student becomes a Junior in the Society on graduation he is entitled to much more of the interest of the Local Section than he received when in college. The distinctly personal work with young men, dealing with matters of social, financial, and economic interest, can be done in a satisfactory manner only by the Local Sections. In several states the Sections are now the recognized leaders in all matters affecting the welfare of the profession. It is the task of the Society to build up strong and active Local Sections in all the states and to encourage them to take leadership in technical papers and research, as well as in the general social and economic welfare, not only of their own members but also of the whole civil engineering profession.

Helping the Younger Men.~The importance of Junior membership to the Society can hardly be overestimated. The class of young men in college which is attracted by membership in Student Chapters will be found to be the able and promising students. These young men can be greatly helped by friendly recognition on the part of older engineers and by being given the opportunity to do active work in the Section.

Where there is a group of fifteen or twenty or more in a single city, some type of association of Juniors appears to be the desirable form of organization. It offers to the young men the opportunity to prepare papers, take an active part in discussion, and really get into worth-while activity in a large way. Where the group of Juniors is small it would appear desirable to put one on each committee, to designate them as aides to the Section officers, and to give them places on technical programs.

The important thing is that these young men are just entering the profession. Their concepts of professional ethics, of high standards of practice, and of engineering loyalty are being formed. They are entitled to proper classification of position and to adequate pay and to a right to prove themselves worthy of advancement. The inspiration that they can gain from membership in the Society, from the acquaintance with old and successful engineers, and from the advice and counsel of the members of the Section will be of lasting value in the making of the great engineers of a few years hence.

Engineering is a great profession and to keep it so its members must recognize their responsibility to the younger men who are entering it. The engineering society is in fact, and must recognize itself as being, the graduate school in which young engineers gain that knowledge of professional relations, ethical conduct, and ideals of good practice that can be secured nowhere else.

Technical Divisions Prevent Disintegration.~Any study of American engineering literature would be compelled to give to the Society credit for the greatest contribution to engineering knowledge and literature in America made by any organized group of engineers. It has done a magnificent job, but in the doing has failed to recognize sufficiently the divergence of engineering interest and the growth of many new fields of specialization.

The question may well be asked whether or not the Founder Societies have been remiss in not caring for specialized fields of technical interest much earlier than they did. Could not the work of such organizations as the American Welding Society, American Illuminating Society, and other highly specialized technical groups, have been done just as well by wisely organized technical divisions of some of the Founder Societies?

It appears certain that the splendid work of our Sanitary Engineering Division is just as good as it would be if the same men were organized as an American Society of Sanitary Engineers. Each Technical Division should be in effect a technical agency operating within the Society of Civil Engineers, and making use of its organization, staff, and publications.

Leadership in Nation-Wide Problems.~With such an organization, with a loyal membership made up of the leading civil engineers in the country, uniformly strong in all the states, financially sound, and with well-established and favorably known publications, the Society is, as it should be, the one professional society which is in the best position to help individual members of the profession in difficult times like the present. It should assume leadership in many matters.

The most annoying problem of the present day is that of unionization. With labor leaders active in the attempt to bring every employee group into some form of union organization, with official pressure being brought to bear to compel such affiliation, many young engineers need some professional society or group to turn to for advice and support. The true answer is that engineering is a profession and not a trade. The labor union does not solve the engineer's problems, and he has no rightful place in the unions because his professional obligation makes him the umpire between the owner and builder, or between the public and the contractor on public works. Unless the engineer is a member of a professional society which can and will speak for him he has little chance of having his argument listened to.

The time is apparently here when the engineers of the United States must take the position very definitely that engineering is a profession—yes, a learned profession—reached only by years of study and training and experience in design, construction, or research; and that the obligation placed on the engineer by his profession to exercise independence of judgment, to be fair and impartial, honest and unbiased, is wholly inconsistent with any form of employee unionism. The obligation is just as binding on the engineer employee of the railroad, power company, city, state, or manufacturing plant as it is on the consulting engineer.

Representing the Whole Profession.~And if it be true that these problems face the profession today then it is equally true that the profession must speak through its societies. They must give more thought to registration and the enforcement of registration laws; to such matters as political discrimination against engineers, unjust discharge, and many other matters that involve the relationships of the engineer employee of city, state, or federal government; to the merit system in civil service; to proper classification of employees, and not only to the fixing of adequate salaries for each class, but to insisting that those salaries be paid.

If present conditions persist, this Society and all other engineering societies will have to do these things in an organized way and to a much greater extent if the young engineer or the employee engineer is going to have his profession speak for him with the same degree of authority that the trade union speaks for its members.

It would appear to be self-evident that any engineering society to achieve real success must be primarily a technical society having as its objective the highest standards of technical, professional, and ethical practice. Furthermore, it should deal with all economic problems which are involved in engineering construction and should fearlessly express its opinion and assume leadership in the formulation of broad economic policies of state and national interest. It should, through its Sections, extend its activities to include also the financial and economic well-being of its members. Failure to do so will result in the attempt to organize new societies with this objective. It is obvious that in times like these the long-established and financially solvent Founder Societies are in much better position to accomplish definite results than any new group whose energies must be devoted largely to organizing and securing members.

The Society has a record of eighty-six years of fine accomplishment. The standards of membership, ethics, and practice have always been of the highest, and every change in the past has been to raise these standards. They should never be lowered. The Society is aristocratic in the sense that it takes into its membership only those who have proved themselves to be of high personal and professional standing. Its traditions must be kept.

It is such an organization, and only such, that should be looked to for leadership by the engineering profession; and this leadership must be in all matters that pertain to the social, economic, and political welfare of the engineer as well as in his practice, ethics, and scientific perfection.

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Volume 8 Number 8

Diesel and Turbo-Electric Streamliners

A Review of Recent Developments in Railroad Transportation, and a Preview of a New-Type Locomotive

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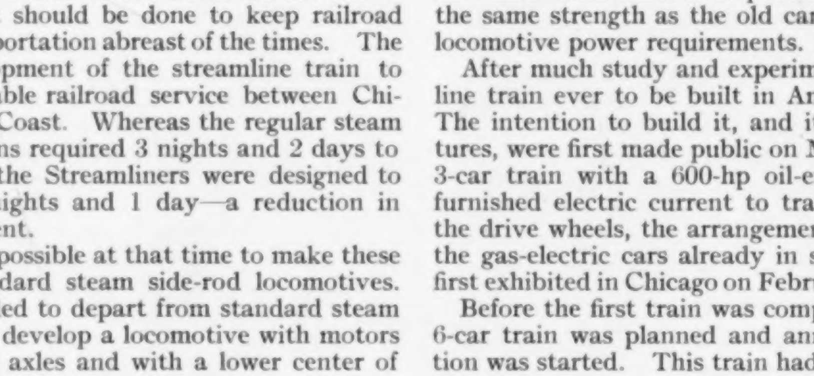
THIS is a story of twentieth-century pioneering in railroad transportation—of the development of the high-speed, light-weight passenger train that is the railroads' answer to highway and airway competition. It begins with a brief description of the Union Pacific's Diesel-powered Streamliners—from the first 3-car model of 1934 to its 17-car successors of 1938. It tells next of the engineering study that has gone into making these trains comfortable, and safe, and economical of operation. And it concludes with a description of a new-type locomotive, not yet in service—a veritable steam-electric central station on wheels—with which these twentieth-century pioneers expect to achieve new economies and still better performance. The article is an abridgment of Mr. Kahler's paper on the program of the Society's 1938 Annual Convention.

ABOUT 1932 the Union Pacific Railroad set out to determine what should be done to keep railroad passenger transportation abreast of the times. The result was the development of the streamline train to provide fast, comfortable railroad service between Chicago and the Pacific Coast. Whereas the regular steam limited passenger trains required 3 nights and 2 days to cover that distance, the Streamliners were designed to make the run in 2 nights and 1 day—a reduction in travel time of 40 per cent.

It was not thought possible at that time to make these speeds with the standard steam side-rod locomotives. It was therefore decided to depart from standard steam railroad practice, and develop a locomotive with motors geared to the driving axles and with a lower center of gravity. This would make unnecessary expensive changes in track construction and would permit the new locomotive to take the curves at higher velocity than was possible with the "standard" type. The locomotive was also to be designed so that the entire run from Chicago to the Pacific Coast could be made without changing engines. Further, the fueling and watering distance was to be increased to 500 miles. Studies were also made with the idea of providing light-weight cars of the same strength as the old cars, thereby reducing the locomotive power requirements.

After much study and experimenting the first streamline train ever to be built in America was constructed. The intention to build it, and its descriptions and pictures, were first made public on May 24, 1933. It was a 3-car train with a 600-hp oil-engine generator, which furnished electric current to traction motors geared to the drive wheels, the arrangement being very similar to the gas-electric cars already in service. The train was first exhibited in Chicago on February 14, 1934.

Before the first train was completed the building of a 6-car train was planned and announced, and construction was started. This train had a 900-hp Diesel-engine generator. In experimenting with it, it developed that higher speeds were necessary, so a 1,200-hp Diesel engine was installed. A seventh car was also added. This train is now the "City of Portland," which operates between Chicago, Ill., and Portland, Ore. It was the first streamline train in America to have sleeping-car equipment, and the first streamline train in transcontinental service. In October



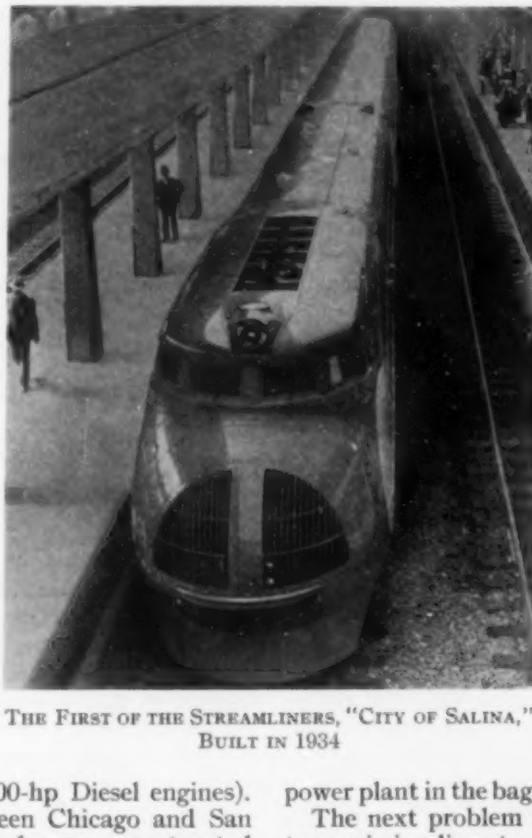
The "City of San Francisco"—A 5,400-Hp, 17-Car Streamliner Operating Between Chicago and San Francisco

1934 it broke all speed records between the Pacific Coast, Chicago, and New York, and these records still stand.

Another train of 11 cars, with 2,100 hp in a 2-unit locomotive, was built in 1935 to operate between Chicago and Los Angeles; and at the same time another 11-car train was built with 2,400 hp and two Diesel engines to operate between Chicago and San Francisco. These were the largest Diesel installations ever used for passenger trains up to that date.

Later two other trains of 12 cars each, with two-unit 2,400-hp Diesel-engine locomotives similar to the San Francisco train but with additional improvements, were constructed and put into service between Chicago and Denver—a distance of 1,048 miles.

Two more trains of 17 cars each were then built. These were to be hauled by 3-unit locomotives of a total capacity of 5,400 hp (each unit having two 900-hp Diesel engines). These trains, which operate between Chicago and San Francisco and Chicago and Los Angeles, were constructed jointly by the Union Pacific, the Southern Pacific, and the Northwestern railroads. The locomotives are the largest Diesel-electric passenger locomotives in existence, and the trains themselves incorporated numerous facilities never before available in any passenger service.



THE FIRST OF THE STREAMLINERS, "CITY OF SALINA," BUILT IN 1934

Apart from the locomotive, the new trains themselves presented some difficult problems in design. For example, the development of a truck that would provide easy riding at high speeds required a good deal of experimenting before it was finally accomplished. Another problem was to provide some method of communication between the train crew and the motorman.

LIGHTING FACILITIES, AIR CONDITIONING, AND HEATING

A number of attempts had been made in the past to install telephones on steam trains, but they had not been successful. However, after some experimenting a satisfactory telephone system was finally developed. It was so successful, in fact, that a second system was later installed which permitted the passengers to telephone the dining car and club car for service. Also, each of the staterooms, compartments, or roomettes on the Pullman cars was provided with a telephone connection.

With the Diesel locomotive no steam was available for heating the train, and small steam oil-fired flash boilers were installed for this purpose. As the length of the train increased, the weight of the boilers and the water became excessive—and there remained, of course, the difficulty encountered in conventional steam trains of getting sufficient heat to the rear cars during extreme cold weather. Accordingly, on the two newest streamline trains—the "City of San Francisco" and the "City of Los Angeles"—the cars were equipped with electric heaters, and about one-half of the heating supplied was by electricity and the remainder by steam. Less than 45 kw per car is necessary for proper heating. Thus far, experience indicates that possibly less fuel oil will be required to heat the train electrically than by steam.

Lighting facilities and air conditioning have also been improved The power requirements for lighting have been increased from about 1 kw to about 4 kw per car, and adequate air conditioning is now provided even through desert country where temperatures of over 125 F are not uncommon.

The use of electricity for heating, air conditioning, lighting, ventilation, water cooling, and other apparatus on these trains made it necessary to supply about 50 kw per car in electric power for auxiliary train service, as compared to the 2 to 4 kw required by conventional passenger cars. This large amount of power would considerably increase the tractive effort necessary to haul the cars if axle generators were used, and would thus nullify to some extent the efforts of the designers to provide light-weight cars. Consequently, it was decided to provide an auxiliary Diesel electric power plant in the baggage car at the head end of the train.

The next problem that had to be considered was the transmission lines to carry this much power through the trains. The conventional steam trains use direct current at 32 volts. On the first Streamliner this voltage was increased to 64 volts in order to cut down the size of cables. As the trains lengthened out and the required current increased it was again found necessary to increase the voltage to 220 volts, and to use 3-phase alternating current in order to keep down the size of the transmission wires. Further study is now being given to this problem with the view of using 440- or 550-v 3-phase current.

One serious difficulty encountered with the heavy cables was the jumpers connecting the cars, which had to have large receptacles and plugs. On some of the trains with 220-v current there are 6 or 7 of these receptacles between the cars, which makes uncoupling quite a problem. Consideration is now being given to the possibility of a single transmission line extending through the train and operating at 2,300 v. Transformers would be used for stepping down to the motor and lighting voltages. The receptacles and plugs on the jumpers would be smaller than those required at the lower voltages, but the matter of providing safe insulation and clearances still presents serious problems.

PROBLEMS IN LOCOMOTIVE DESIGN

Having thus noted some of the problems in connection with the design of the train itself, let us go back to the locomotive. For the speeds at which trains are now operating it is necessary to provide a locomotive of between 5,000 and 6,000 hp. Thus far the Diesel locomotive is the only type of motive power which has been able to perform this service, using one locomotive for the entire run. The fuel consumption of the Diesel-powered train is also materially less than that of the ordinary steam train, despite the fact that it operates at materially higher speeds.

It is not possible at this time to give accurate figures on the repair expense of the Diesel locomotive. Many of

the expenditures made thus far have been for improvements and experimental work which cannot be accurately separated from the costs incident to regular maintenance.

During the past two or three years the Union Pacific Railroad has purchased a number of modern steam locomotives which are a considerable improvement over the older steam locomotives. The alloy metals used in the main and side rods and reciprocating parts have materially reduced the counterbalance problems. However, to obtain power comparable to the Diesel locomotive it has been necessary to make the axle loads much greater than is necessary with the latter, which has the load distributed over more driving axles. Also, the maximum horsepower can only be obtained at, say, from 45 to 65 miles per hour; on the Diesel locomotives it is nearly constant at all speeds.

If a larger Diesel engine suitable for locomotive service is developed, it is probable that a much better Diesel locomotive can be built than at present.

"A Traveling Steam-Electric Power Plant"

About four years ago the General Electric Company started studying the possibilities of building a steam-turbine electric locomotive which could be used not only in general railroad service but also in high-speed streamline train service. Later the Union Pacific became interested, and in 1936 arranged for the construction of a 2-unit locomotive of this type, of not less than 5,000-hp total capacity.

This locomotive, soon to be placed in operation, is really a traveling steam-electric power plant with all the refinements of the modern central station. The boiler plant on each unit consists of a high pressure boiler with superheater, economizer, and air heater built in one compact unit. The boiler is to generate steam at 1,500-lb pressure, with a total steam temperature of 900 F, the output of each boiler to be 45,000 lb of steam per hour.

Steam is piped from the boiler unit to the main turbine, a multistage cross-compound type whose high and low pressure stages drive through separate pinions the single gear connected to the main generator. The turbines and generator operate at constant speed and are fitted with a speed-governing mechanism for holding the speed constant over the load range.

The exhaust steam from the low-pressure turbine is piped back through the locomotive to an air-cooled condenser. The condensate then flows by gravity to the hot well, from which it is pumped through closed feedwater heaters to the boiler. This makes a closed circuit, and it is estimated that the water necessary to make up the losses will amount to only about 2 per cent of the steam generated. Because of this arrangement it will not be necessary to carry a large tender of water for the boiler, such as is required with the conventional steam locomotive, and consequently the weight of the locomotive will be materially reduced.

Power Unit of One of the New Streamliners

The turbines are to operate at a speed of about 12,500 rpm, there being a 10-to-1 gear ratio so that the generator will operate at about 1,250 rpm. From the generator, electric current is transmitted to 6 traction motors on each unit. The control apparatus is so arranged that each unit can be operated as a separate locomotive, and that one engine crew can operate the 2 units when they are coupled together.

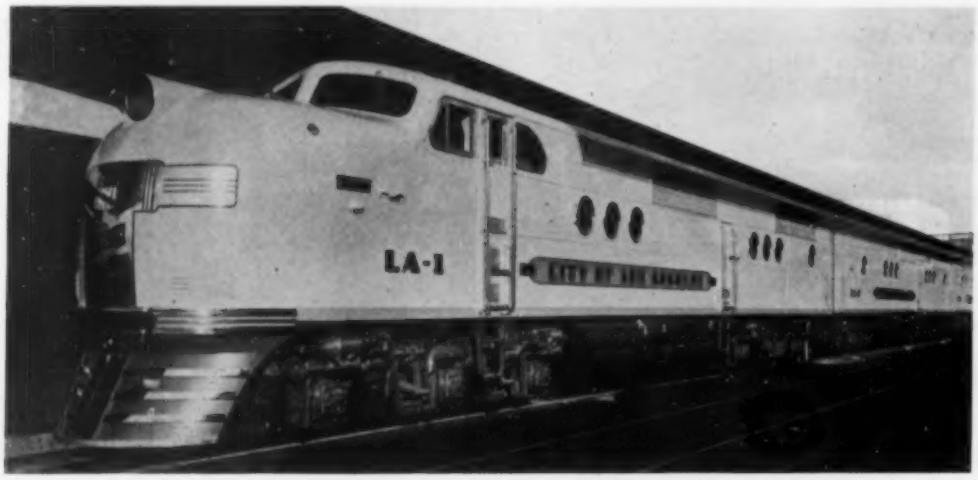
Inter-Car Telephones Add the Final Touch to These Modern Hotels on Wheels

Each unit is carried on 2 trucks, there being a 4-6-6-4 wheel arrangement. Geared to each driving axle is a 600-hp, direct-current, series-wound motor.

The 2-unit locomotive is to weigh about 500 tons, and the weight on each driving axle will be about 57,000 lb. The tractive effort at starting of the 2-unit locomotive will be about 162,000 lb, and the continuous tractive effort, with 120-C temperature rises and normal forced ventilation, will be about 61,200 lb. The cab and general outside appearance of each unit will be very similar to the latest streamline train locomotives of the Union Pacific.

The boiler was built by the Babcock and Wilcox Company and is known as a steam motive type. It can be used for other purposes than locomotives. Control of the quantity of oil, water, and air is automatic and is in a definite correct relation for economic combustion. The water, after leaving the boiler feed pump, is discharged through a feedwater heater and economizer to the boiler tubes. It then passes through the boiler tubes to a separator, where such of the water as is not evaporated is taken out and sent to the hot well, the intention being to pump through the tubes more water than can be evaporated. From the separator the steam passes to the superheater, where its temperature is raised to about 900 F.

The oil and air are introduced into the top of the boiler. When ignited, the hot gases pass down one vertical section of the boiler and up another, and thence through the superheater tubes, economizer tubes, and air-heating tubes to the stack. Before the air reaches the boiler it passes over the outside of the air-heater tubes, thus aiding combustion when it comes in contact with the oil.



THE "CITY OF LOS ANGELES," TWIN OF THE "CITY OF SAN FRANCISCO"
Both Trains Were Completed in December 1937

The air-cooled condensers are divided into 24 sections. They are mounted vertically along the sides of the locomotive in the back third of each unit, and have round copper tubes, finned type. The air cooling is done by four 64-in. impeller-type condenser fans, driven by a steam turbine.

AUXILIARY EQUIPMENT

Connected to the main generator shaft is an auxiliary generator which is to supply 3-phase, 60-cycle current at 220 v for operating the train lighting, air conditioning, heating, and other facilities.

In order to provide steam at about 200-lb pressure for train heating there is a heat exchanger or evaporator, consisting of a coil immersed in the boiler water. Steam for this coil can be supplied direct from the main boiler or extracted from the main turbine when the latter is operating. The water level in the evaporator, and the quantity of steam generated, are automatically controlled. This apparatus not only supplies steam for heating the train but also provides distilled water for make-up water to the main boiler.

Each locomotive unit will carry about 4,000 gal of water in tanks at the extreme front of each unit; this quantity is necessary because of the large amount of steam required for train heating. The fuel oil tanks are located at the back of each unit near the condensers. About 3,000 gal of fuel oil are to be carried on each unit.

When the first Streamliner was designed a more efficient brake system was thought necessary, since it was desired to stop the train at 100 miles per hour in about the same distance required for a train of conventional design running at about 60 miles per hour. Also a more uniform rate of retardation was desired in order to reduce to a minimum the discomfort to the passengers. A braking system to meet these requirements was put into successful operation on the first Streamliner. It was designed and built by the New York Air Brake Company, and was a wide departure from conventional practice.

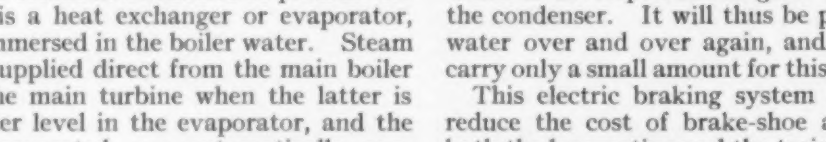
This highly efficient braking system, of course, made the wear and tear on the brake shoes and the rims of the car and locomotive wheels much greater than on the conventional trains. In order to eliminate or at least reduce this trouble, the new steam-turbine locomotive will be equipped not only with the new air brakes but with electric brakes as well.

On electric railroads such brakes are not new. However, electric railroads have a trolley wire to which to deliver the current generated by the traction motors, while Diesel-electric or turbo-electric locomotives on steam railroads do not. The use of grid resistances to dissipate the electric energy would add materially to the weight of the locomotive. Hence the steam turbine electric locomotive will have pipe resistance grids, a new practice on locomotives. Water is to be pumped through the pipe grids to carry away the heat, and the steam which is developed in the grids is to be discharged into the condenser. It will thus be possible to use the same water over and over again, and it will be necessary to carry only a small amount for this purpose.

This electric braking system should very materially reduce the cost of brake-shoe and wheel renewals on both the locomotive and the train.

Some of the economies which it is hoped will result from the use of steam-turbine electric locomotives are as follows:

The fuel cost may possibly be less than that for the Diesel locomotive. (The thermal efficiency will not be as good as that of the Diesel engine, but the cost of the lower grade of fuel oil to be used on the steam-turbine locomotive will make up for this.)



A GLIMPSE INTO THE FUTURE
Model of the Steam Turbo-Electric Locomotive Which Is Nearing Completion

The lubricating oil cost will be less than on the Diesel locomotive.

The repair cost should also be low and may be materially lower than for the Diesel locomotive.

Finally, at the present time it is possible to build a steam-turbine electric locomotive in a larger single unit than any other locomotive except one which operates with a trolley wire

Fatigue Tests of Riveted Joints

By Wilbur M. Wilson

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Of vital importance to the mechanical engineer, in the design of machine parts, is the phenomenon known as fatigue of metals. As certain members of bridges and other civil engineering structures may likewise be subjected to several million stress cycles, the structural engineer is also coming to consider fatigue as a possible cause of failure. But fatigue strength is so much a function of the size and shape and surface condition of the member in question that previous investigations, confined to tests of small machined-and-polished specimens, are of little value to him. Professor Wilson presents here, in concise form, a digest of his extensive research with specimens that are in reality fabricated structural members. His full paper, which was on the program of the Structural Division at the 1938 Annual Meeting of the Society, is an abstract of Bulletin 302 of the University of Illinois Engineering Experiment Station.

The tensile strength of structural steel members has been and sometimes still is considered as the product of the unit strength of the steel and the area of the section of the member. Experience with machine parts has shown that, because of the phenomenon known as the fatigue of metals, a large number of reversals of stress or a large number of repetitions of stress of the same sign will cause failure, even though the maximum load divided by the area of the section is considerably less than the unit static strength of the material.

Comprehensive investigations have been made to determine the fatigue strength of various engineering materials in which small machined and polished specimens were used. Among other things, it has been learned that the fatigue strength of the specimen depends on the shape of the specimen and the finish of the surface as well as on the physical properties of the material of which the specimen is made.

The members of steel structures such as bridges are not subjected to as frequent repetitions of stress as the moving parts of machines. But some of the early steel bridges have some members that have been subjected to a few million stress cycles, and some of these members have failed. This, together with the experience of the mechanical engineer with machine parts, has led the structural engineer to consider fatigue as a possible cause of failure of structural members. The fact that the size and shape and the condition of the surface of small fatigue specimens greatly affects their fatigue strength, indicated that tests of small machined specimens were of little value in determining the fatigue strength of structural members. What appeared to be needed was tests of specimens which are in reality fabricated structural members as large as it is feasible to test. This paper is a report of tests of this character.

OBJECT AND SCOPE OF INVESTIGATION

The object of the investigation was to determine the fatigue strength of riveted joints connecting structural steel plates. All rivets were in double shear and all had a nominal diameter of 1 in. Some specimens were designed for rivet failure, others for plate failure. The variables studied included the transverse distance between rivets; relation between unit shear, unit bearing, and unit tension; combinations of carbon-steel and manganese-steel rivets with carbon-steel, silicon-steel, and nickel-steel plates; and the methods of making holes—punched full size, sub-punched and reamed, and drilled from the solid. The specimens were subjected to axial stress only, and for most of the tests the stress in the specimen during a stress cycle varied from zero to a maximum tension.

For the purposes of this investigation, the fatigue strength of a riveted joint has been arbitrarily defined as the maximum stress to which the specimen can be subjected 2,000,000 times without failure. A value of the fatigue strength corresponding to failure at 2,000,000 cycles has been computed from tests for which failure occurred at other than 2,000,000 cycles by use of the empirical equation,

$$F = S\left(\frac{N}{2{,}000{,}000}\right)^{0.10} \qquad \ldots\ldots\ldots\ldots [1]$$

in which F is the fatigue strength corresponding to failure at 2,000,000 cycles, and S and N are the maximum unit stress and number of cycles for failure, respectively, for a given test for which failure was at other than 2,000,000 cycles.

Specimens were made in groups of three identical specimens each, and the fatigue strength reported is the average of three tests in each instance.

DISCUSSION OF THE TESTS

Tests of Specimens Designed to Fail in the Rivets.—A large number of specimens designed to fail in the rivets have been tested, but lack of space makes it impossible to include more than the following very general statements relative to the results.

The tests for which the stress varied from zero to a maximum were fairly consistent and indicate that the fatigue strength of the rivets is approximately 30,000 lb per sq in. shear on the rivets. (Here and elsewhere in this paper the term "stress" denotes average stress. The actual stress may, and usually does, have quite a different value in certain localized areas.)

The tests for which there was a complete reversal of stress were very inconsistent, the fatigue strength of the rivets in shear being as high as 30,000 lb per sq in. for some specimens and as low as 15,000 lb per sq in. for others.

Apparently many factors affect the fatigue strength of rivets subjected to a reversed shear. These, together with an outline of tests that appear to be desirable, are given in the complete report.

Tests of Specimens Designed to Fail in the Plate.—A large number of specimens designed to fail in the plate have been tested. The stress range in the cycle is from zero to a maximum tension for all series except the one for which the ratio of the minimum to the maximum stress is the variable being studied.

Effect of the Relation of the Minimum to the Maximum Stress in the Stress Cycle on the Fatigue Strength of Plates.—The tests of Series B12 were planned to determine the effect of variations in the relation of the minimum to the maximum stress in the stress cycle on the fatigue strength of the plate. The details of the specimens are shown in Fig. 1(*a*). As originally fabricated, each specimen contained six 1-in. rivets in double shear, and the tension–shear–bearing (*T:S:B*) ratio was 1.0:0.40:0.84. The tests of the specimens designed to fail in the rivets indicated that rivets have a high fatigue strength, so the middle two rivets were drilled from several of the B12 specimens, thereby changing the *T:S:B* ratio to 1.0:0.60:1.26, which is more nearly in line with the design of joints subjected to static loads. The results of the tests are summarized in Table I.

Extensive tests of small machined specimens have resulted in the expression,

$$(FL)' = \frac{3\,(FL)}{2 - r} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

for the endurance limit of forged and rolled steel for various relations between the minimum and maximum stress in the stress cycle. (See *Materials of Engineering*, by Herbert F. Moore, page 55, fifth edition.) In this expression FL is the endurance limit for a complete reversal, r is the ratio of minimum to maximum stress (r is negative for a complete or partial reversal), and $(FL)'$ is the endurance limit for any particular value of r. Equation 2 was developed for small machined specimens and is not necessarily applicable to the fatigue strength of the plates of riveted joints. Nevertheless it is of interest, in considering the fatigue strength for various ratios of minimum to maximum stress, to compare the values obtained from this expression with the experimental values. This is done in Table I, Col. 5, using as a base the experimentally determined fatigue strength for complete reversal. The tests are limited in number so that the results cannot be considered final; but a close agreement is noted.

Effect of Method of Making Holes on Fatigue Strength of Plates.—Three groups of specimens were used in tests

TABLE I. EFFECT OF THE RELATION OF THE MINIMUM TO THE MAXIMUM STRESS IN THE STRESS CYCLE ON THE FATIGUE STRENGTH OF PLATES OF RIVETED JOINTS

Specimens shown in Fig. 1(*a*): 1-in. carbon-steel rivets driven with hydraulic riveting machine; carbon-steel plates; holes sub-punched and reamed. Static strength of plates, 63,725 lb per sq. in.

Stress Cycle	Stress Ratio, r	No. of Tests Averaged	Fatigue Strength of Plates, Lb per Sq. In.	
			By Test	From Eq 2
(1)	(2)	(3)	(4)	(5)
Complete reversal . . .	−1	4	19,700	19,700
Zero to maximum tension	0	5	28,600	29,500
Maximum tension to tension one-half as great . .	$+^1/_2$	3	39,000	39,400

planned to determine the effect that the method of making holes has on the fatigue strength of the plates. Three kinds of holes were used: (1) sub-punched $^1/_4$-in. and reamed; (2) punched full size; and (3) drilled from the solid. Each of the three groups of specimens includes three combinations of plate and rivet materials, as follows: carbon-steel plates and carbon-steel rivets; silicon-steel plates and carbon-steel rivets; and silicon-steel plates and manganese-steel rivets. All specimens, shown in Fig. 1(*b*) and 1(*c*), had 1-in. rivets driven with a hydraulic riveting machine.

A summary of the results is given in Table II. The evidence is quite conclusive that, for the specimens tested, the method of making the holes did not affect the fatigue strength of the plates. It should be noted, however, that the thickness of the plates was only $^1/_2$ in. and the diameter of the holes was $1^1/_{16}$ in.

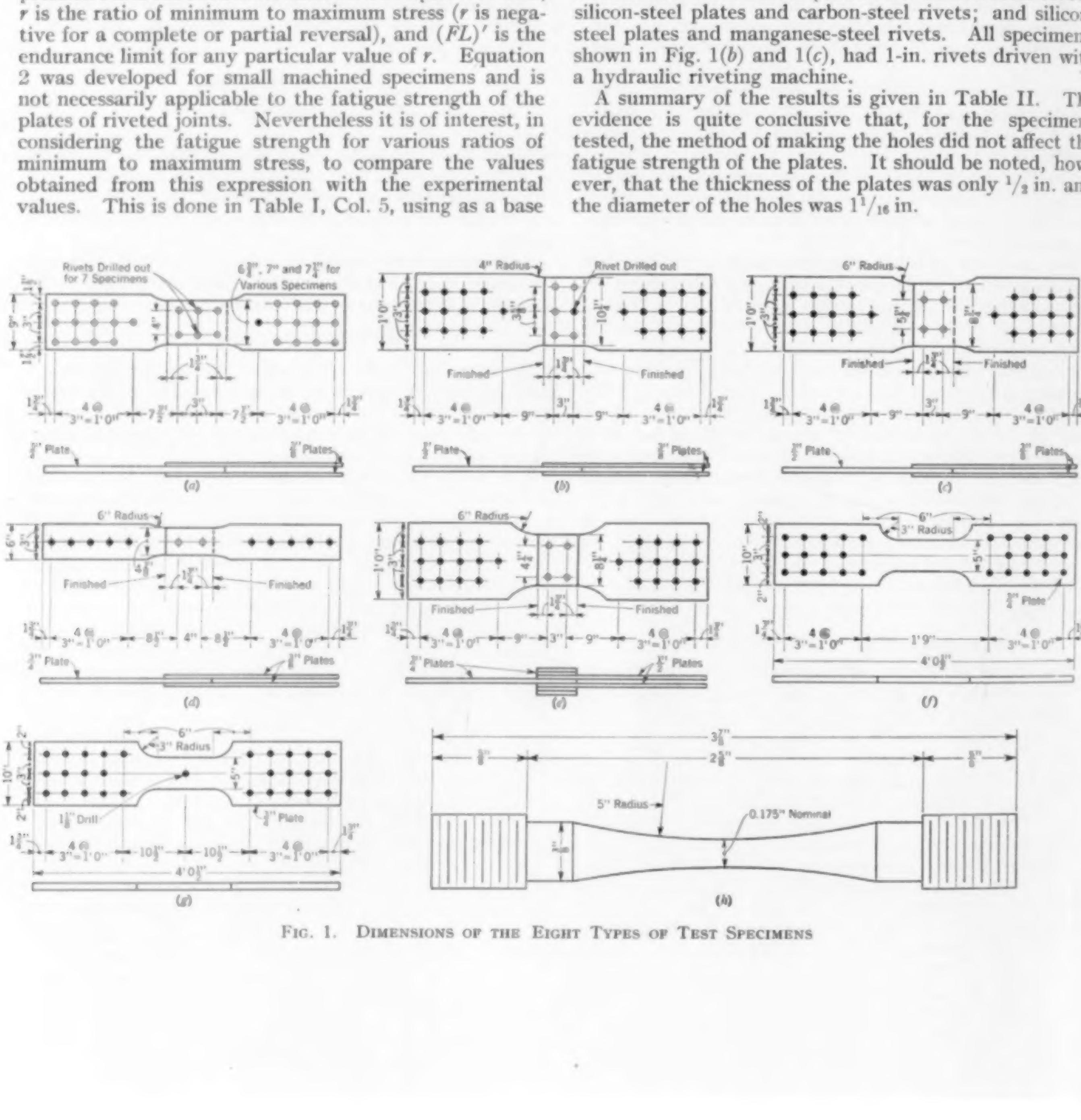

FIG. 1. DIMENSIONS OF THE EIGHT TYPES OF TEST SPECIMENS

Relative Fatigue Strength of Carbon-Steel, Silicon-Steel, and Nickel-Steel Plates.—The tests described in the previous section were planned to also give the relative fatigue strength of carbon-steel and silicon-steel plates. The data of Table II are rearranged in Table III for this latter study. It would appear from Table III that carbon-steel plates and silicon-steel plates have approximately the same fatigue strength when connected with carbon-steel rivets. The tests also indicate that the fatigue strength of silicon-steel plates was very much less when connected with manganese-steel rivets than when connected with carbon-steel rivets.

TABLE II. EFFECT OF METHOD OF MAKING HOLES ON THE FATIGUE STRENGTH OF PLATES—SUMMARY OF RESULTS

Each Individual Value Is Average of Three Tests

Method of Making Holes (1)	Series No. (2)	Kind of Steel in: Rivets (3)	Plates (4)	Strength of Plate, Lb per Sq In.: Static (5)	Fatigue (6)
Sub-punched $^1/_4$-in. and reamed	B18(Fig. 1*b*)	Carbon	Carbon	63,200	26,700
	B21(Fig. 1*b*)	Carbon	Silicon	90,425	30,000
	B24(Fig. 1*c*)	Manganese	Silicon	91,000	21,100
				Average	25,900
Punched full size	B19(Fig. 1*b*)	Carbon	Carbon	63,625	28,100
	B22(Fig. 1*b*)	Carbon	Silicon	90,425	27,900
	B25(Fig. 1*c*)	Manganese	Silicon	91,000	22,300
				Average	26,100
Drilled	B20(Fig. 1*b*)	Carbon	Carbon	63,625	29,600
	B23(Fig. 1*b*)	Carbon	Silicon	90,425	26,600
	B26(Fig. 1*c*)	Manganese	Silicon	91,000	23,700
				Average	26,600

T : S : B ratio: 1.00 : 0.44 : 1.38 for B18 to B23; 1.00 : 0.48 : 1.50 for B24, B25, and B26.

Because of the commercial importance of the relative fatigue strength of carbon-steel and silicon-steel plates, it seemed desirable to make additional tests of specimens made of the two kinds of plate material. The specimens used in the second series are shown in Fig. 1(*d*). Three of them (Series B7) are of carbon-steel plates, and three (Series B10) of silicon steel. All specimens are geometrically identical, all have 1-in. carbon-steel rivets driven with a hydraulic riveting machine, and the holes for all specimens were sub-punched $^1/_4$ in. and reamed. The *T:S:B:* ratio is 1.00:0.72:1.50. The static strength of the control specimens is 62,875 lb per sq in. and 88,800 lb per sq in. for the carbon steel and silicon steel, respectively. The fatigue strength of the plates, the average of three tests in each instance, is 23,900 lb per sq in. and 23,300 lb per sq in. for the carbon steel and the silicon steel, respectively.

TABLE III. RELATIVE FATIGUE STRENGTH OF CARBON-STEEL AND SILICON-STEEL PLATES—FIRST SERIES

Each Individual Value Is Average of Three Tests

Materials	Series No.*	Fatigue Strength, Lb per Sq In.
Carbon-steel rivets and carbon-steel plates	B18	26,700
	B19	28,100
	B20	29,600
	Average	28,100
Carbon-steel rivets and silicon-steel plates	B21	30,000
	B22	27,900
	B23	26,600
	Average	28,200
Manganese-steel rivets and silicon-steel plates	B24	21,100
	B25	22,300
	B26	23,700
	Average	22,400

* For specimens B18 to B23, see Fig. 1(*b*). For specimens B24 to B26, see Fig. 1(*c*).

The grip of the rivets for all the specimens described in the preceding paragraphs of this section is small, being $1^1/_4$ in. for Series B18 to B26, inclusive, and $1^1/_2$ in. for Series B7 and B10. Because increasing the grip of short rivets increases the initial tension in the rivets, a third series of tests to determine the relative fatigue strength of carbon-steel, silicon-steel, and nickel-steel plates was planned for which the grip of the rivets is $4^3/_4$ in. These specimens (Fig. 1*e*) all have 1-in. rivets driven with a hydraulic riveting machine, and all holes were sub-punched and reamed. The *T:S:B:* ratio is 1.00:0.72:1.50. The plate-and-rivet material combinations, and the results of the tests, are given in Table IV.

All three series of tests that were planned to show the relative fatigue strength of carbon-steel and silicon-steel plates gave the same results, namely, the fatigue strength of plates of the two materials are very nearly the same even though the static strength is very much greater for the silicon steel than it is for the carbon steel. Likewise, the fatigue strength is not appreciably greater for nickel-steel plates than it is for carbon-steel and silicon-steel plates.

Consider the specimens of the third series (Table IV) having silicon-steel plates. Those with manganese-steel rivets had a somewhat greater fatigue strength than those with carbon-steel rivets, a relation the reverse of that reported in Table III. The rivets of the third series had a long grip and the tension in the rivets was probably greater for the manganese-steel than for the carbon-steel rivets, a condition the reverse of what is believed to have existed for the tests reported in Table III.

TABLE IV. RELATIVE FATIGUE STRENGTH OF CARBON-STEEL, SILICON-STEEL AND NICKEL-STEEL PLATES*

Materials	Series No.	Fatigue Strength Lb per Sq In.*	Static Strength of Plate Material Lb pe Sq In.
Carbon-steel rivets and carbon-steel plates	B27	25,900	63,600
Carbon-steel rivets and silicon-steel plates	B28	25,600	80,200
Carbon-steel rivets and nickel-steel plates	B29	26,700	99,000
Manganese-steel rivets and silicon-steel plates	B30	27,800	80,200

*Each value the average of three tests.

Effect of Geometrical Properties of Specimens on Fatigue Strength of Structural Steel.—It is well known that surface imperfections and sudden changes in section act as "stress raisers" and affect the fatigue strength of a specimen if the latter is based on the "average" stress at the section of failure, the universal custom. It appeared desirable, therefore, to make tests to determine the fatigue strength of structural steel using specimens of various geometrical forms. The specimens used include plates with mill scale on the two sides but no holes or connections, and with machined edges as shown in Fig. 1(*f*); plates with mill scale on the two sides, a $1^1/_8$-in. drilled hole and machined edges, shown in Fig. 1(*g*); and small, carefully machined, round specimens, shown in Fig. 1(*h*). For each type there was one group of specimens of carbon structural steel, one of silicon structural steel, and one of nickel structural steel.

The small, carefully machined, round specimens were tested by Prof. H. F. Moore, using a Moore-Krouse machine equipped for cycles of direct axial stress varying from zero to a maximum tension.

A summary of the results of the tests on specimens of various types is presented in Table V. In computing the average values of the fatigue strength of the plates

TYPICAL FATIGUE FAILURES
Left, Plate of Riveted Joint; Right, Bar with Drilled Hole

of riveted joints given in this table, only the B27, B28, and B29 series were included. The other specimens were excluded in order that the specimens with the three plate materials—carbon steel, silicon steel, and nickel steel—might all have the same geometrical properties. It is of interest to note that the fatigue strength of a plate with mill scale on the two sides is only two-thirds as great as the fatigue strength of machined-and-polished specimens. Drilling a hole in a plate still further reduces the fatigue strength, but the fatigue strength of a plate of a riveted joint is greater than the fatigue strength of a similar plate containing an open hole.

SUMMARY OF RESULTS

"Fatigue strength of riveted joints" as used in this paper is defined as the maximum stress to which the joint can be subjected 2,000,000 times without failure. For tests for which failure occurred at other than 2,000,000 cycles, the fatigue strength was computed from the maximum stress in the stress cycle and the actual number of cycles for failure, by means of Eq. 1. The tests appear to justify the following conclusions:

1. The limited number of tests that were made to determine the influence of the ratio of the minimum to the maximum stress in the stress cycle on the fatigue strength of the plates of a riveted joint, indicate that Eq. 2, which has been developed from tests of small machined specimens, is applicable to the plates of the riveted joints of Series B12 of this investigation (Table I).

2. The method of making the rivet holes—punching full size, sub-punching $^1/_4$ in. and reaming, or drilling from the solid—did not affect the fatigue strength of either carbon-steel or silicon-steel plates of the specimens tested.

3. The fatigue strength of the plates in a riveted joint of balanced design is approximately 26,000 lb per sq in. This value is practically the same whether the plates are of carbon steel with a static strength of 63,000 lb per sq in., of silicon steel with a static strength of 80,000 lb per sq in., or of nickel steel with a static strength of 99,000 lb per sq in.

4. Fatigue tests of small machined-and-polished specimens have little value as an indication of the fatigue strength of riveted structural members.

Although this investigation has been fairly comprehensive, the results are so important that additional tests should be made.

The first impression relative to the results of the tests reported in this paper is one of alarm. The second is that they are not in accord with experience because the fatigue strength of plates reported is less than the unit stress permitted in re-rating old bridges, and these bridges have given fairly satisfactory service. Mature reflection, however, shows that both of these impressions are wrong. In designing structures for static loads, the maximum possible stresses are used. These can only be produced by a combination of circumstances that seldom occurs during the life of the structure. Occasional overstress appears to contribute nothing to the possibility of a fatigue failure. For this reason, probable frequency of occurrence as well as the intensity of the stress should be considered in checking against fatigue failure. Any load combination considered in the static check need not be considered in the fatigue check if it is not likely to occur more than a few thousand times during the life of the structure. This does not mean that the possibility of a fatigue failure should be ignored. Instead it is intended to emphasize that danger of fatigue failure depends on two factors: (1) the intensity of the unit stress; and (2) the number of repetitions of the stress that will occur during the life of the structure. If one of these factors is increased, the other must be decreased in order that the structure may be safe against fatigue failure. Likewise, if one is decreased the other may be increased without endangering the safety of the structure. It is believed that the knowledge that has been gained will, when properly interpreted, lead to designs that are both safe and economical.

TABLE V. FATIGUE STRENGTH OF STRUCTURAL STEEL AS DETERMINED BY TESTS OF VARIOUS TYPES OF SPECIMENS

Type of Specimen	Strength, Lb per Sq In.		Ratio of Fatigue Strength to Static Strength	Ratio of Fatigue Strength to Fatigue Strength of Polished Specimen†
	Static	Fatigue*		
(1)	(2)	(3)	(4)	(5)
			CARBON STEEL	
Polished (Fig. 1*h*)	64,700	47,000	0.73	1.00
B37 (Fig. 1*f*)	61,800	30,300	0.49	0.67
B37 (Fig. 1*g*)	61,800	21,200	0.34	0.47
Plates of riveted joints	63,600	25,900	0.41	0.56
			SILICON STEEL	
Polished (Fig. 1*h*)	81,700	56,000	0.69	1.00
BS37 (Fig. 1*f*)	80,800	35,800	0.44	0.64
BS37 (Fig. 1*g*)	80,800	23,900	0.30	0.43
Plates of riveted joints	80,200	25,600	0.30	0.43
			NICKEL STEEL	
Polished (Fig. 1*h*)	99,000	74,000	0.75	1.00
BN37 (Fig. 1*f*)	99,000	39,500	0.40	0.53
BN37 (Fig. 1*g*)	99,000	24,300	0.25	0.33
Plates of riveted joints	99,000	26,700	0.27	0.36

* Stress cycle: Zero to maximum tension for all specimens. Each value is average for three tests except for machined-and-polished specimens; for the latter the values are the averages of four or more tests.

† Corrected for variations in the strength of the steel on the basis that, for a given kind of steel, the fatigue strength of a machined-and-polished specimen varies as the static strength.

ACKNOWLEDGMENTS

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The Colorado–Big Thompson Project, Colorado

Trans-Mountain Diversion Will Bring Water from Western Slope of Continental Divide to 800,000-Acre Area in Northeastern Colorado

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The Colorado–Big Thompson project provides for diverting headwaters of the Colorado River, on the western slope of the continental divide, to lands in need of supplemental irrigation on the eastern slope. Its estimated cost is $44,000,000. Although irrigation is its chief purpose, it is estimated that 900,000,000 kwhr of electrical power will ultimately be developed annually in connection with the diversion.

Mr. Preston first reviews the numerous surveys that have been made, beginning in 1889, to determine the feasibility of a trans-mountain diversion of Colorado River water. He then describes the Grand Lake area, and the various reservoirs, tunnels, and other features of the present project. In addition he discusses the economic justification for the project and the plan for repaying the cost of construction.

The first authentic information of record on contemplated diversions of water from the headwaters of the Colorado River to the South Platte basin is House Bill No. 161, passed by the state legislature of Colorado in the spring of 1889, authorizing the expenditure of $25,000 for the survey and construction of a canal along the western slope of the continental divide to cut across the range and supplement the supply in South Boulder Creek. From this survey it was determined, as stated in the Fifth Biennial Report of the State Engineer, that such a canal was not feasible.

The engineer in charge was therefore instructed to make careful examinations of the highest sources of water supply in the various branches of the Grand (Colorado) River, from Grand Lake south to South Boulder Pass. It was concluded that if such a collection canal were built, a diversion tunnel not less than three miles long would be required through the continental divide. Such an undertaking at that time seemed bigger and more difficult than a 13-mile tunnel would seem today.

The Fourth Annual Report (1905) of the Bureau of Reclamation disclosed a plan for a proposed development of the Colorado River in the vicinity of Grand Lake. This development contemplated raising the elevation of Grand Lake by 20 ft, and constructing a 13-mile tunnel under the continental divide to connect the lake with either the Big Thompson or the St. Vrain on the eastern slope. Between 1905 and 1933, several other surveys and studies developed much basic data, especially the study and report made by R. J. Tipton in 1933 for the state engineer. These data were found very helpful in the investigations undertaken in 1935 by the Bureau of Reclamation.

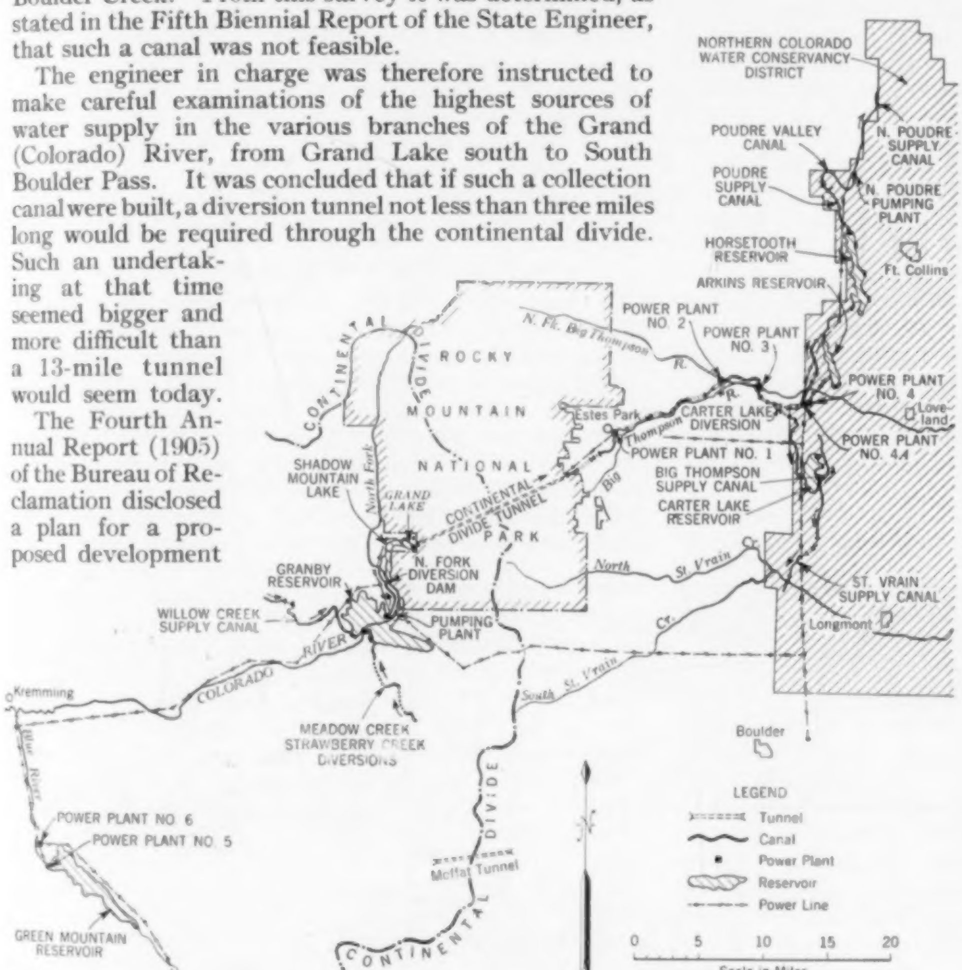


Fig. 1. Principal Features of the Colorado–Big Thompson Project

Only the Extreme Western Portion of the Northern Colorado Water Conservancy District Is Shown Here. The District Extends Eastward Some 150 Miles, Along Both Sides of the South Platte, to Julesburg, in the Northeast Corner of the State

In August 1935, $150,000 of PWA funds was allotted to the U. S. Bureau of Reclamation for surveys and investigations of the proposed Colorado–Big Thompson project. More than two years of study showed this project to be among the more feasible of those investigated.

Grand Lake in Colorado is a natural body of water at the base of the precipitous western slope of the Rocky Mountains. It owes its existence to a long narrow terminal moraine which was left as a dam across the valley when the glacial ice melted. The lake, which has a normal water surface at 8,369 ft above sea level, is one of the major keys in the project plans (Figs. 1 and 2). Its inclusion permits the use of a shorter tunnel at this elevation than would otherwise be possible.

The lake is extremely picturesque, and attracts an increasing number of tourists each summer. The village of Grand Lake is rapidly becoming one of the favorite recreation centers of Colorado, and on completion of the Colorado–Big Thompson project it is believed that it

may become one of the most popular in the country. With the addition of Shadow Mountain Lake, which will enlarge Grand Lake over $2^1/_2$ times without changing its water level, the attractiveness of this area will be increased immensely. Every precaution has been taken in planning the project to eliminate the undesirable features that now exist near Grand Lake. One of these is the mosquito-breeding swamp land which will be flooded by Shadow Mountain Lake. About thirty additional acres of swampy area will be built up by spoil from the west half of the tunnel and will be leveled and landscaped to create desirable building and recreational ground. A similar disposition of the spoil will be made at the east portal of the tunnel. Practically every feature of the project has been designed with a view to enhancing the scenic and recreational values of the area.

In order to justify the diversion of so large an amount of water from the western slope, it was necessary to make a thorough study of those irrigated and arable lands fit for irrigation that lie between Grand Lake and the Colorado–Utah state line. The results obtained from these studies show that within the Colorado River basin, including tributaries exclusive of the Gunnison, 256,000 acres are now being irrigated and an additional 122,830 acres are arable. Only a part of the arable land could ever be irrigated, because it is so widely scattered. From these studies, it is apparent that if Colorado is ever to utilize her share of the water allocated by the Colorado River Compact of 1922 to the upper basin states, she must divert surplus waters of the Colorado to other lands than those found in the Colorado River basin. The Colorado–Big Thompson project offers an opportunity to do this.

FORMATION OF THE NORTHERN COLORADO WATER CONSERVANCY DISTRICT

A law recently passed by the Colorado state legislature provides for the creation of conservancy districts for making improvements of this nature and for levying assessments to cover the costs of construction of irrigation works. Under this law the district may levy a tax of not to exceed one mill upon all the taxable property of the district, and not to exceed $^1/_2$ mill additional to cover delinquencies in collections. On May 2, 1938, the Colorado Supreme Court, in a unanimous decision, upheld the validity of this Colorado Water Conservancy District Act.

Under this law the Northern Colorado Water Conservancy District was formed, with a taxable valuation estimated at $150,000,000. A one-mill tax will repay about one-fourth the irrigation costs of the Colorado–Big Thompson project. The other three-fourths will be derived from the sale of water. Some lands will require as little as $^1/_4$ acre-ft per acre, and others as much as $1^1/_2$ acre-ft to supplement their present supply.

This Northern Colorado Water Conservancy District includes 800,000 acres under canals, and 615,000 acres of this area is irrigated at the present time. The additional water supply for this area is to be derived from about 780 sq miles of drainage area above Hot Sulphur Springs, west of the continental divide in Grand County, Colo., and varying in elevation from 8,050 to 14,000 ft.

In accordance with the Reclamation Law, the cost of constructing the project is to be repaid over a period of 40 years. The annual cost is estimated at $2.00 per acre-ft per year. This amount is less than the present cost of storage water in that vicinity. Moreover, economic studies, covering a number of years, show that the annual value of crops will amount to five or more times the annual cost of the water.

About 50 cents of the annual construction cost per acre-foot will be paid by an ad valorem tax of one mill on all assessable property in the District. It is believed that this plan of raising a part of the needed revenues by taxing all property within the district, will permit the development of projects that otherwise would be impossible because of the farmers' inability to pay the entire cost.

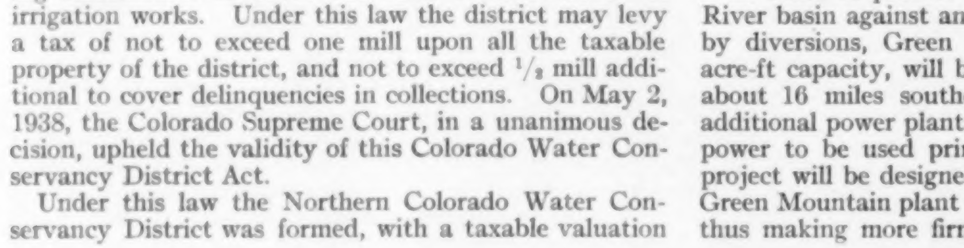
It is planned that the power development will be carried out after the completion of the irrigation features. The plants (Figs. 1 and 2) will be built as the power market develops, with the exception of power plant No. 1, which will supply power for operation of the project.

The power features of the project are considered secondary, the main purpose being irrigation. However, ultimately this project will produce more than 900,000,000 kwhr of power annually (including both primary and secondary output). Studies are now being made by several agencies to determine some of the future uses for this cheaper available power. It is believed that demand will probably be made for power for municipal use, for rural electrification, and for the development of low-grade ore reserves. These and other markets that may materialize in the near future will probably require the full development of the power possibilities.

GENERAL DESCRIPTION OF THE PROJECT

In order to protect the water users in the Colorado River basin against any depletion of their water supply by diversions, Green Mountain Reservoir, of 152,000 acre-ft capacity, will be constructed on the Blue River about 16 miles southeast of Kremmling, Colo. Two additional power plants at Green Mountain will develop power to be used principally for peak loads, and the project will be designed to use off-peak power from the Green Mountain plant for pumping at Granby Reservoir, thus making more firm power available for sale.

The Granby Reservoir, to be formed by an earth and rock-fill dam 228 ft in height, will have a capacity of 482,000 acre-ft. It will be used to store the excess water of the Colorado River, supplied by melting snow during May, June, and early July. From it the water will be pumped through an average lift of 130 ft into a canal leading to Shadow



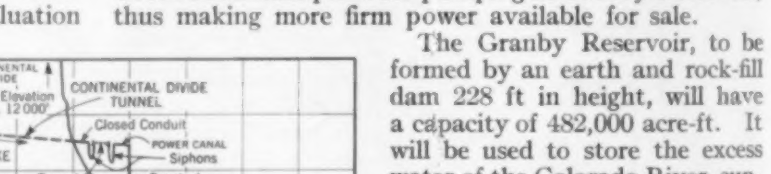
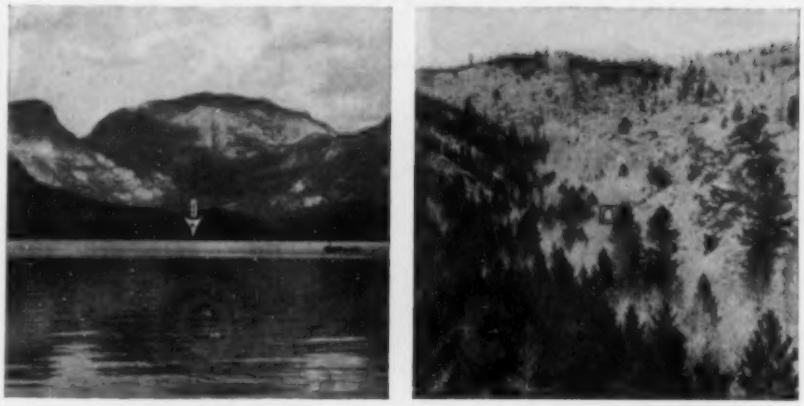


FIG. 2. DEVELOPED PROFILE OF COLORADO–BIG THOMPSON PROJECT, COLORADO

Mountain Lake, which will be at the same elevation as Grand Lake and connected to it by the present outlet of the latter.

From Grand Lake the water will flow by gravity through the 13-mile tunnel under the continental divide; then fall more than 2,800 ft through the five power plants that will eventually be constructed along the Big Thompson Canyon. It will then be stored in Carter Lake and in the Horsetooth and Arkins reservoirs.

Shadow Mountain Lake, with an area of 1,356 acres, will be formed by the North Fork diversion dam, a concrete overflow structure 38 ft in height. As this dam will be downstream from the confluence of the Grand Lake outlet with the North Fork of the Colorado River, it will divert to Grand Lake not only the pumpage from the Granby Reservoir, but also a part of the natural flow of the North Fork.



WHERE A 13-MILE TUNNEL WILL PIERCE THE CONTINENTAL DIVIDE: GRAND LAKE TO WIND RIVER CANYON, SOUTHWEST OF ESTES PARK

The Portal Locations Are Indicated near the Center of Each Picture

The Granby pumping plant will contain three motor-driven vertical-shaft pumping units having a total capacity of 900 cu ft per sec with full reservoir and 550 cu ft per sec at low water. The canal leading to Shadow Mountain Lake will have a capacity of 900 cu ft per sec, and will operate throughout the year—even with the temperature as low as 40 deg or more below zero, Fahrenheit. The latent heat in the water pumped from a depth of 100 ft or more below the surface of the reservoir will prevent the water from freezing and will keep a large area open in Shadow Mountain Lake.

The west tunnel portal is to be connected with Grand Lake by an open channel 800 ft long. At the lake end of this channel a concrete weir will be placed, with a permanent crest that will prevent a lowering of the lake of more than 1 ft below its present elevation.

The largest unit of the project, the Continental Divide Tunnel, is to be of horseshoe shape, 9.5 ft in inside diameter, 69,023 ft in length, and lined throughout with a 9-in. (average) concrete lining. It will extend from the easterly end of Grand Lake to Wind River, northwest of Estes Park village.

Power plant No. 1, to be constructed to operate the project, will be located on the south bank of the Big Thompson River about half a mile downstream and east of Estes Park village. It will contain two 15,000 kva generators, direct-connected to vertical-shaft, single-runner, spiral-casing type turbines operating under an effective head of 704 ft. The power output of this plant will be one-third of that now produced in the state of Colorado and sold by public service companies. Less than one-fourth of this will be used for pumping water from Granby Reservoir into Shadow Mountain Lake.

Until there has developed a sufficient market for power to justify the construction of power plants Nos. 2, 3, 4, and 4-A, the water will be turned into the Big Thompson at power plant No. 1 and carried by that stream to a diversion dam about midway between the present diversion dam and the power plant for the town of Loveland.

The storage system to deliver water into the headwaters of the east-slope streams consists of Carter Lake Reservoir and the St. Vrain supply canal delivering water to the St. Vrain River, and the Big Thompson supply canal delivering water to the Big Thompson; Horsetooth Reservoir and Poudre canal, which regulate the discharge into the Poudre River; and the North Poudre supply canal and pumping plant delivering water to the North Poudre canal. The Arkins Reservoir regulates the deliveries of water into the Big Thompson River. These reservoirs provide storage of 256,000 acre-ft. The canals are high enough to serve all existing canals except the North Poudre canal, and are designed to deliver 310,000 acre-ft (the total annual diversion) in a period of 60 to 75 days.

PRESENT STATUS OF PROJECT

The repayment contract with the federal government for the construction of the irrigation features of the Colorado–Big Thompson project was approved on June 28, 1938, by a seventeen-to-one majority of the qualified voters of the Northern Colorado Water Conservancy District. After the contract has been signed by the Secretary of Interior (it has already been approved by him as to form), contracts for the construction of the various project works will be advertised and awarded from time to time as funds are made available.

Appropriations and allotments totaling $4,150,000 have already been made. The construction of power lines to the east and west portals of the Continental Divide Tunnel and to the Green Mountain Dam site will be one of the first steps in the program. The Green Mountain and Granby dams will also be started this year. Contracts for these works will probably be advertised late in July or early August, and the contract for the Continental Divide Tunnel will probably be let by fall. Construction of this tunnel will take from five to six years, depending on the amount of funds made available from year to year. The present plans outline a program, whereby the various features of the project, except power plants Nos. 2, 3, 4 and 4-A, will be complete and ready to go into operation upon completion of the Continental Divide Tunnel.

The Colorado–Big Thompson project will be the fourth largest Bureau of Reclamation project in the country, and the largest government project ever proposed in the State of Colorado. Its estimated total cost is $44,000,000, of which $25,000,000 is for irrigation features and $19,000,000 for power development.

Details and estimates were worked out in the Denver office of the Bureau of Reclamation under the following divisions: canals, H. R. McBirney; reservoirs, K. B. Keener; power, L. N. McClellan; hydraulics, E. B. Debler; field work, M. E. Bunger; and economic study, R. L. Parshall, U. S. Department of Agriculture. The Bureau of Reclamation is in the Department of the Interior, Harold L. Ickes, secretary. All Bureau work is under the direction of John C. Page, commissioner. R. F. Walter is the chief engineer of the Bureau; S. O. Harper the assistant chief engineer; and J. L. Savage the chief designing engineer.

Water Power in Brazil

With Special Reference to the São Paulo Development

By A. W. K. Billings

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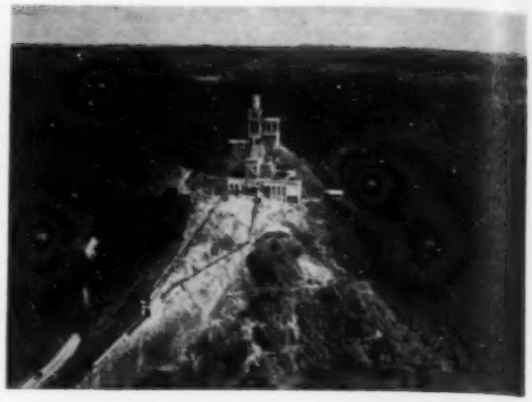
São Paulo, Brazil



The Surge Tank at the Top of the Serra
In the Background, the Plateau, with an Arm of the Pedras Reservoir Visible near the Center

In no other country are physical conditions so favorable for the development of hydroelectric power on a large scale as in Brazil, which occupies more than half the area and contains more than half the population of South America. Preeminent among the projects already constructed in whole or in part is the São Paulo development, described here. This article is abridged and brought up to date from a lecture given by Mr. Billings before the Institution of Civil Engineers in London in June 1936 and repeated before the Michigan Section of the Society in February 1938. Permission of the Institution to reproduce the drawings and the abridged text from its "Journal" is gratefully acknowledged.

When Brazil is mentioned, the average person immediately thinks of the Amazon and of the country tributary to it—but the real Brazil is very different. The enormous region of the Amazon is sparsely settled, and its climatic conditions will probably never permit industrial development. In southern Brazil, however, the climate favors the development of a great industrial population, and it is in that region, also, that the major possibilities for hydroelectric development exist.

Estimates of the potential water power of Brazil range from 15,000,000 to 60,000,000 hp. However, the visible waterfalls thus catalogued are secondary in economic importance to the invisible water power obtainable by diversion. Nearly all the great waterfalls are relatively inaccessible and suffer the serious disadvantage of very high back-water in the flood season, and it seems certain that they will have a negligible part in the economic future of the country. Only those powers which can be developed commercially within a reasonable period and are close enough to the centers of population to command a market are worth study and tabulation.

Let us turn our attention to that portion of Brazil lying east of the Paraná River and between parallels of latitude 20 and 25 deg south (Fig. 1). In this region the cooler and healthful climate favors the development of large cities and towns with their industries, while natural conditions facilitate to an extraordinary extent the hydroelectric installations that serve and stimulate them. Rio de Janeiro has a population of 1,800,000; São Paulo, primarily industrial, has 1,250,000. In this region hydroelectric plants, depending on their size and extent of regulation of flow, cost roughly the same as thermal power plants; the expenditure on fuel for thermal power is, however, so heavy that thermal plants have no economic part in the power picture.

He who travels by sea along the coast of this part of Brazil sees, for several hundred miles, what appears to be a mountain range—the Serra do Mar (Fig. 2). Geologically it is a fault, or series of faults, as it forms the edge of a great plateau about 2,500 ft above sea level. In past ages the nearly level lower plain rose slowly, breaking along these faults parallel with the present coast. The rise, with the accompanying tilting toward the interior was, however, rapid enough, geologically speaking, to prevent the rivers which drained the plain from keeping pace with the rise by cutting down their courses to the ocean. The result is that, with few exceptions, the present rivers of this region follow the gentle slope of the plateau inland until they join the Paraná River; they then flow southwest and only join the ocean at the river Plata, more than 2,500 miles from their sources.

Topography and Rainfall Favor Water Power Development

The slope of these rivers in their upper courses (Fig. 3) is very small, with a starting fall of about 1 in 3,000; hence the rains that fall on the plateau form sluggish rivers which flow away from the coast. Along the narrow, hot coastal plain the annual rainfall is from 72 to 96 in., and along the crest of the plateau from 180 to 240 in.; it decreases inland to about 48 to 60 in. In the vicinity of the installation to which special attention will be given here—namely, the Serra do Cubatão plant near São Paulo—the rainfall at the crest averages 190 in. per year, and in wet years amounts to 270 in. In wet

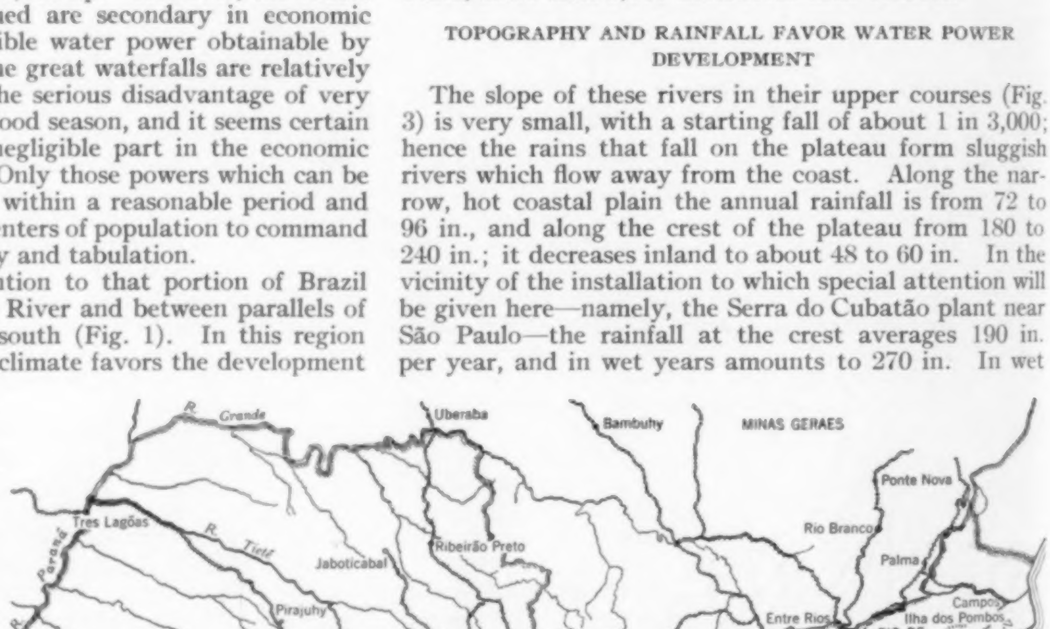


Fig. 1. General Map of the São Paulo–Rio de Janeiro Region

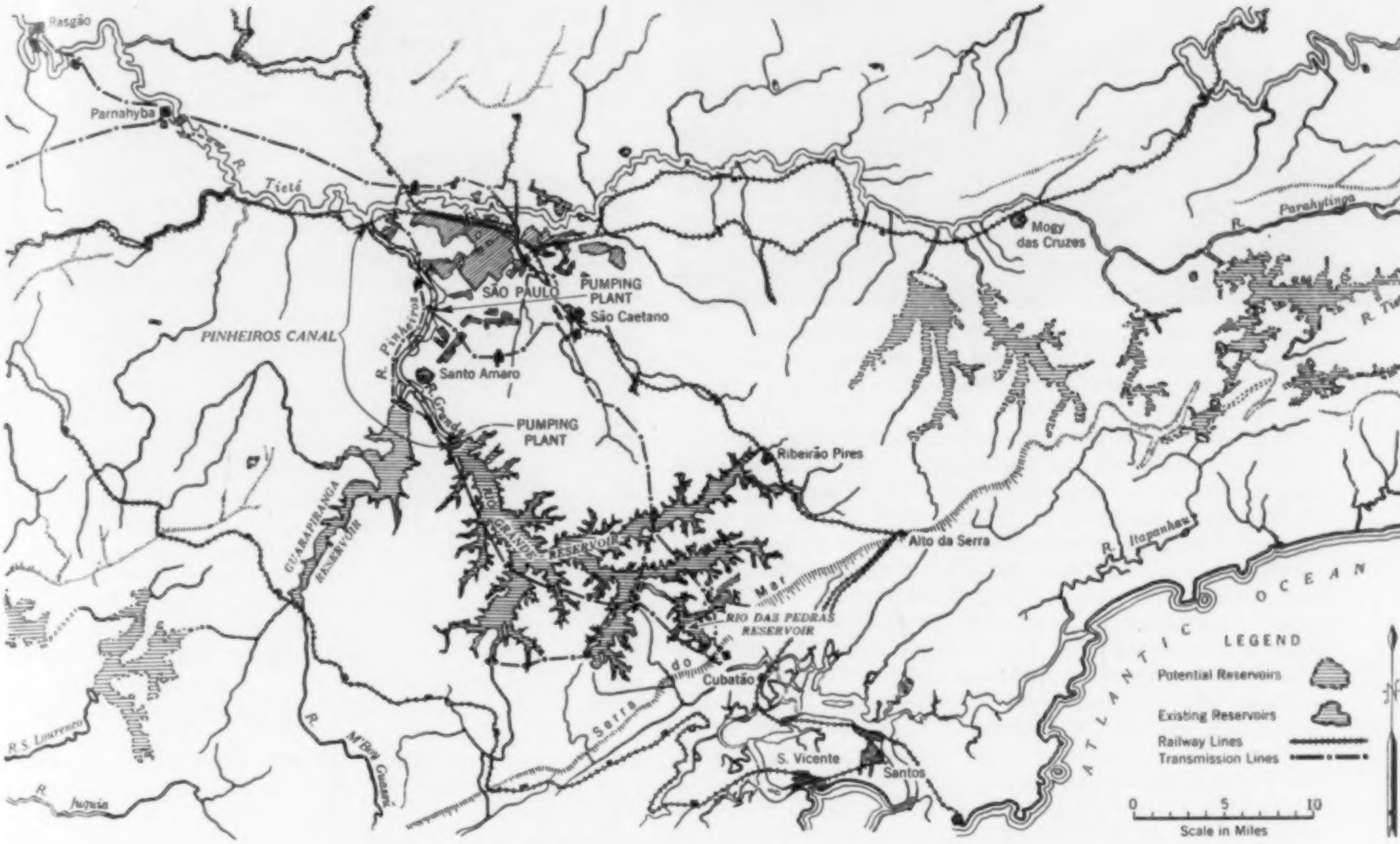


FIG. 2. THE SERRA DO CUBATAO DEVELOPMENT

months the rainfall reaches 52 in., and the heaviest downpour observed since this work began is $7^1/_2$ in. in 1 hour and 20 minutes. The effect of such rains on the very steep slope of this fault zone has to be seen to be appreciated. The combination of heavy average rainfall, high head, favorable topography, sparse settlement of reservoir sites, and proximity to a large and rapidly growing market and to the sea, as in this part of Brazil, is rare.

From topographic maps it is apparent that a dam 90 ft high on the Tieté River a few miles below the city of São Paulo would form a lake 106 sq miles in area at an elevation of 2,408 ft above sea level, and that when this elevation was reached the impounded waters would commence to flow in the other direction to the ocean, over the lowest depression in the almost imperceptible divide near the edge of the plateau. This flow could thus be utilized in the drop of 2,380 ft to the coastal plain. It would be impracticable, however, to build such a lake, for it would flood most of the city. The obvious alternative is to go upstream on the main river and on certain of its affluents, select dam sites, and build reservoirs which can be interconnected and from which the water can be brought, as needed, to the edge of the plateau and to the power station at its base.

This simple idea is the basis of the Serra project. In its original form the project consisted of a main reservoir on the affluent called the Rio Grande, which, at a maximum height of 2,421 ft above sea level, had an area of 26 sq miles and a volume of 311,000 acre-ft. This was to be supplemented by 12 smaller reservoirs to be built successively as needed, and the surplus flow of each, after discharging downstream the normal flow of the dry season, was to be diverted by canals and tunnels to the pipe lines and power-house suitably located at the base of the Serra opposite the port of Santos.

Further study during the initial construction period showed that it was advantageous to raise the level of the main reservoir by 22 ft, thus increasing the area to 44 sq miles and the useful volume to 835,000 acre-ft, equivalent to 1,700,000,000 kwhr reserve storage. The other reservoirs were only slightly modified but the canals and tunnels connecting them to the main reservoir were eliminated. In their stead one important canal was projected, by which not only the previously available surplus flow of the affluents, but also the floods and surplus flow of the Tieté itself, could be diverted to the main reservoir and to the power station by low-head pumping, through a lift of from 40 to 100 ft.

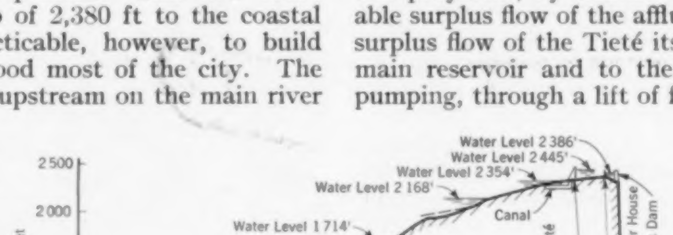


FIG. 3. PROFILE OF UPPER TIETÉ RIVER VALLEY AND SERRA DO CUBATÃO POWER DEVELOPMENT

This change seems complicated but is, in fact, a definite simplification and improvement, and the further reduction of the Tieté floods thus made possible is a great benefit. It should be noted that there are no irrigation demands downstream. The later reservoirs now authorized will have a total storage of 1,270,000 acre-ft, equivalent to 2,600,000,000 kwhr additional reserve storage.

The Pedras Dam, Which Forms the Headwater Pond
Beyond the Limits of the Picture, to the Right, Is
the Tunnel Intake

The first large reservoir, the Rio Grande (Fig. 2), with the small reservoir leading the flow to the crest of the Serra, gives a regulated flow sufficient for 246,000 hp at 60-per cent load factor. The diversion to the coast of the flow of the second large reservoir—the Guarapiranga, built in 1908 to provide partial regulation for one power plant on the Tieté River—gives 140,000 hp more. This flow is obtained by discharging the water, when convenient, from the reservoir into the rectified channel of the Rio Grande River and pumping it through a 25 to 85-ft difference of level into the Rio Grande reservoir. Further supplies, up to 550,000 hp as an economic limit, can be obtained by pumping the flow of the Tieté River up the rectified channel of the Pinheiros River through one step of 15 ft and then the one just mentioned of 25 to 85 ft into the main reservoir. Even this does not complete the project; the ultimate capacity and the order of development of further water supplies will be determined by economic conditions of the future, which cannot be predicted accurately at present.

Evidently this development must be considered, not as a single installation but as a flexible program of many steps, each to be carried out when needed. This will take care of the growth of load during perhaps the next 20 to 30 years. Up to the present over $30,000,000 has been spent. The ultimate total will depend upon the capacity which is found to be justified.

GENERAL DESCRIPTION OF PROJECT

The two main pumping stations mentioned will have an ultimate capacity of 73,000 and 39,000 hp, corresponding to 8,300 to 10,000 cu ft per sec, depending on reservoir and canal elevations; the initial units now being installed in each plant are of 6,400 hp only. All these units are made reversible so that they can operate as generating units at a minute's notice. They can thus assist in carrying the load at times of emergency. It is expected later to extend these periods of reversed operation, so as to assist regularly in carrying the day load in the dry season, repumping at night the water thus discharged in addition to pumping the flow normally available. It is possible also, to a limited extent, to continue pumping flood waters even when the main reservoir is full, in order to assist in the reduction and control of the floods at the Tieté. The benefits to the city of São Paulo due to this partial flood control are important.

The first large reservoir, the Rio Grande, has been completed. The dams are made by the hydraulic-fill process, the more important ones having plain concrete corewalls extending to the underlying rock for protection against burrowing animals and ants. More than 10,000,000 cu yd of earthwork have been placed in the various dams, dikes, road diversions, and similar features, for this reservoir, while the second step in the project—the canals for rectification of the Pinheiros River—involves about 16,500,000 cu yd more. This is being moved cheaply by centrifugal dredging or by hydraulic sluicing, using electric power. The main canal will be over 200 ft wide, over 25 ft deep, and 16 miles long. About 6,500,000 cu yd of the required excavation has been done to date, and there are working at present six dredges and two subaqueous rock-breakers.

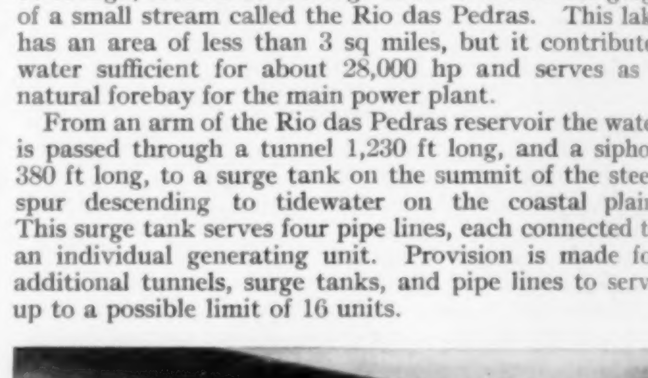
Artificial sand is used exclusively in all the concrete work, as the natural sands of this region are somewhat unreliable, unless carefully washed, due to admixture of clay and organic matter. These methods of using artificial sand, developed over 25 years ago, have been applied with uniform success in Spain, Mexico, and Brazil in placing over 1,000,000 cu yd of concrete.

The preliminary surveys, before construction was started, required many months of tedious exploration, reconnaissance lines, and accurate leveling, on which the subsequent work could be safely based. Such surveys are hampered greatly by the dense undergrowth, which compels the cutting of thousands of miles of trails—veritable tunnels in the mat of vegetation—and slows progress down to a fraction of the ordinary rate in the open. For example, in the not especially difficult topographic survey of the first large reservoir, over 2,500 miles of such trails had to be cut.

At the summit dam on the Rio Grande, where the flow regulated by the larger reservoir is discharged as needed into the smaller one leading to the Serra, three propeller-type turbines, each of 7,000-hp capacity at full head, will be installed to utilize the variable head of 60 ft or less, which would otherwise be wasted.

The smaller reservoir is formed by a concrete dam, 85 ft high, located at the edge of the Serra in the gorge of a small stream called the Rio das Pedras. This lake has an area of less than 3 sq miles, but it contributes water sufficient for about 28,000 hp and serves as a natural forebay for the main power plant.

From an arm of the Rio das Pedras reservoir the water is passed through a tunnel 1,230 ft long, and a siphon 380 ft long, to a surge tank on the summit of the steep spur descending to tidewater on the coastal plain. This surge tank serves four pipe lines, each connected to an individual generating unit. Provision is made for additional tunnels, surge tanks, and pipe lines to serve up to a possible limit of 16 units.



Serra Unit No. 3, with Part of the Generator Housing and Turbine Casing Removed

This Double-Overhung Impulse Turbine Is Rated at 60,000 Hp. Each of the Buckets Weighs Nearly Half a Ton

The first two units, originally rated at 40,000 hp each, are being rebuilt for a maximum capacity of 60,000 hp each; the third unit can deliver 78,800 hp; the fourth and fifth units, the installation of which is now being

Rectification of the Pinheiros River Is Now in Progress
Canal Excavation Will Total 16,500,000 Cu Yd

completed, are rated at 84,000 hp maximum; and the future units will be considerably larger. The present system load factor is over 60 per cent (63 per cent, corrected for growth) and will rise gradually to more than 70 per cent in the later stages.

POWER STATION AND EQUIPMENT

The power station is located over the former bed of the Pedras River, which now forms the tailrace. It is distant by transmission line 26 miles from the center of the city. A railroad siding connects with the Santos docks.

The generating units are of the horizontal double-overhung type, having the generator in the middle between the two bearings with the two wheels mounted, one on each end of the shaft. The normal speed is 360 rpm. The rotating parts of the latest units, the largest yet built of their type, weigh 233 tons, and the complete unit, including stop-valves and hydraulic auxiliaries, weighs 693 tons. On each of the units two independent governors are provided—one for each wheel and nozzle—and are adjusted to slightly different timings to avoid the effect of possible resonant action on pipe-line surges. The normal pressure at the nozzles at no load is about 1,020 lb per sq in.

The jets of the three existing units are $7^{1}/_{2}$, $9^{1}/_{2}$, and $10^{3}/_{8}$ in., respectively, in diameter at (maximum) overload. Chrome-nickel steel is used for the needle tips and nozzle rings. At present 13 per cent chrome steel is used for the buckets of the latest units; the material has to be very resistant and sound and the surface very accurately finished in order to resist the "drop corrosion" produced by spray from the jet. The supply of water to each nozzle is controlled by a hydraulically operated gate valve.

As an example of a modern hydroelectric plant diametrically opposite in design, the Ilha dos Pombos plant on the Parahyba River (Fig. 1), 90 miles northeast of Rio, may be mentioned. This is a "run-of-river" plant without storage. The useful flow, up to about 22,000 cu ft per sec, is diverted by a low dam into a dredged channel $1^{1}/_{2}$ miles long and returned in a fall of 115 ft to the river. When completed, the plant will have a capacity of about 228,000 hp. The design is notable for its simplicity and cheapness when compared with the storage plants in parallel with which such run-of-river plants need to operate. It also has three automatic sector-gates of reinforced concrete, the largest of their type—each 147 ft long, 35 ft in radius, weighing 2,200 tons—which raise the water level 24 ft over the sill and regulate the pool level to within less than 1 in.

STRENUOUS ACCEPTANCE TESTS REQUIRED

In all this work it is considered essential, not only to specify and design each part of the equipment for the extreme emergency condition to which it may be subjected, but also to produce these conditions, as far as possible, in the actual acceptance tests. Each pipe line is therefore tested to that point where incipient but scarcely observable plastic yield is about to occur. This pressure is maintained long enough for a minute inspection of every pipe, joint, saddle pier, and anchor block. Similarly, in addition to the more usual tests, each turbine and generator is subjected to the maximum runaway speed which can occur, and each generator is subjected to a dead short circuit under full-load excitation for 90 sec. For testing hydraulic efficiency the Allen "salt velocity" method is adopted as standard, thus avoiding the uncertainties and disputes arising from the use of current meters. The "Gibson" method is also used on low-head installations.

In high-head projects with large storage reservoirs, evaporation has an importance which is seldom realized. Even though temperatures and winds are moderate and humidity high, the actual evaporation from the water surface of the first regulating reservoir of the Serra development corresponds to a loss of 38,000 hp at 60-per cent load factor; the later steps would bring this loss up to 95,000 hp. This loss, however, is more apparent than real as the previous losses by evaporation from the land surface and by transpiration from the vegetation are eliminated by the flooding.

In this region of Brazil, as in other sections of South America, the rainfall and river flows seem to be more under the influence of the solar cycle than in other parts. Records are meager but indicate that about every 10 or 11 years, just at and following the sun-spot minimum, there occur two, or sometimes three, markedly dry seasons with scanty rainy seasons in between. All calculations of available power must take into account these extremely dry periods. Otherwise, when the successive years of scanty rainfall arrive, disastrous power shortage will occur.

One detail of this project that has been studied carefully, is the possible utilization of this chain of lakes and canalized rivers for barge navigation, but for other than economic reasons it will possibly not be carried out. Although it may appear strange, thorough investigation has shown it to be commercially practicable to transport freight in bulk from the port of Santos to the city of São Paulo, along the waterfront, on these canals; the transfer from coastal plain to plateau, at the edge of the Serra, would be made by ropeway or by barge incline.

This brief outline of so extensive a project gives only an incomplete idea of the simple, yet favorable, natural conditions of this region of Brazil and of the almost unlimited opportunities for hydroelectric development of which the Serra do Cubatão plant is typical.

Beyond the Pedras Reservoir, the Serra Drops Precipitously to the Coastal Plain, 2,400 Ft Below. Santos Lies on the Plain at the Extreme Left. Near the Center, Above the Highway Bridge, Are the Tunnel Entrance and the Surge Tank. Pedras Dam Is at the Extreme Right

Structural Features of the 200-Inch Telescope for Mt. Palomar Observatory

By Mark Serrurier

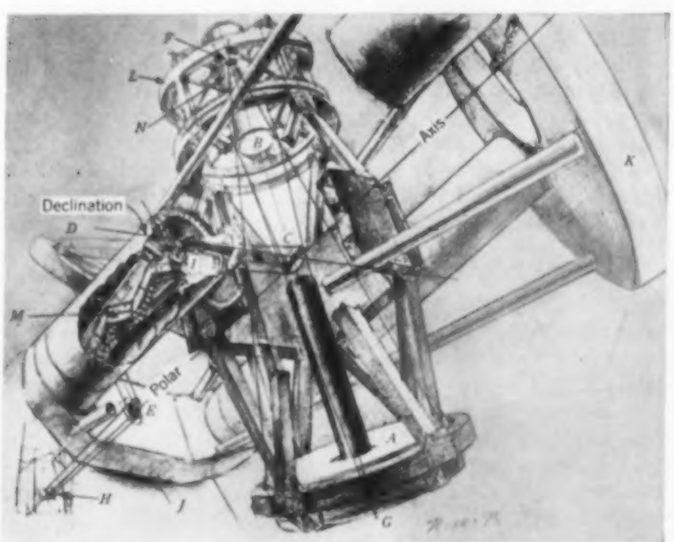
Associate Member American Society of Civil Engineers
Structural Designer, California Institute of Technology, Pasadena, Calif.

For more than three years, parts for the largest telescope in the world have been under construction. Within the next few months they will be assembled in the new observatory of the California Institute of Technology at Mt. Palomar, Calif. With this gigantic eye, astronomers expect to peer a billion light years into space—twice as far as has been possible heretofore.

Among the many specialists who have contributed to its creation is the structural engineer. One of his most important assignments has been to so design the massive moving parts that their deflections will not affect the delicate precision of the instrument. Mr. Serrurier's article is chiefly concerned with the solution of this problem.

By 1940, it is hoped, the new 200-in. telescope for the Mt. Palomar Observatory of the California Institute of Technology will be in operation. Dwarfing its nearest competitor in size—the 100-in. Mt. Wilson reflector—this "new eye for science" has called for the services of specialists in many lines, among them the structural engineer. It is with his problems that the present article is chiefly concerned; it will be well first, however, to consider briefly the general features of the design.

A type of telescope that all engineers are familiar with is the engineer's transit, which astronomers call an alt-azimuth mounting. This very simple type of instrument can be used for visual observation of the stars, but in order to be useful to an astronomer the telescope must be turned by motors or clockwork in such a way that it will follow a particular star. The speeds at which an engineer's transit must be turned about its vertical and horizontal axis in order to follow a star vary in a complicated manner. Also the stars appear to rotate about the optical axis of the telescope. And the machinery necessary to provide these motions would be very complicated.



R. W. Porter

Fig. 1. Phantom View of the Optics

A, 200-In. Mirror; *B*, Convex Mirror; *C*, Coudé Mirror; *D* and *E*, Gantry Mirrors; *F*, Prime Focus (f = 3.3); *G*, Cassegrain Focus (f = 16); *H*, Coudé Focus (f = 30); *I*, Cassegrain Focus (Coudé); *J*, Yoke; *K*, Horseshoe; *L*, Revolving Cage; *M*, Spectrograph Chamber; *N*, Correcting Lenses

The problem is greatly simplified by tilting the vertical axis until it is parallel with the earth's axis of rotation. The required speed of rotation about this axis (which now becomes the polar axis) is then constant and the other two motions are reduced to zero. This type of mounting, known as an equatorial mounting, is used on nearly all large telescopes, including the one discussed here.

The perspective drawings by Mr. Porter (Fig. 1 and the Page of Special Interest) give a fairly complete picture of the Mt. Palomar instrument. The three foci of the telescope are shown—the prime focus at the upper end of the tube, the cassegrain focus at the bottom end of the tube below the mirror, and the coudé focus on the polar axis just south of the mounting. The prime focus is the most important of these because it is where the work on the very faintest stars will be done. The mirrors which change the optical combinations of the telescope are swung into and out of position by electric motors operated from the master control station. Thus the telescope can be made ready for work at any of the foci in a very few minutes.

Variations in atmospheric refraction are so great that corrections must be made for them. However, these variations are so irregular that it is not possible to construct an instrument which will automatically follow the images with sufficient accuracy. The smallest images are about $^{1}/_{1,000}$ of an inch in diameter. Hence accurate guiding of the telescope is done by hand. Nevertheless, it is desirable to make the motor drive as perfect as possible in order to reduce hand guiding to a minimum.

The fact that guiding from a star image by eye is necessary saves the structural engineer much embarrassment in that it is no longer necessary to design a perfectly rigid instrument. Rigidity is important, however, because the movement between the optical parts must be kept within certain narrow limits. Rigidity also reduces the amplitude of vibrations caused by shocks due, for instance, to the astronomer who rides on the telescope as it moves around.

The tube is a structural framework designed to support

Deflections Transverse to Axis of 200" Mirror

	Allowable	Actual
Ross Lens	0.08"	0.03"
Cassegrain Convex	0.10"	0.03"

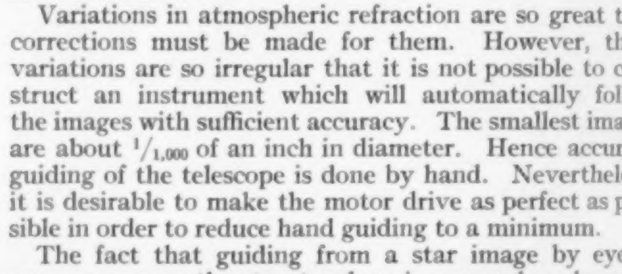


Fig. 2. Permitted and Calculated Deflections of Optical Parts

antos Lies on the Plain at the Extreme Left. Near the Center, Above the Highway Bridge, Are the Tunnel Entrance and the Surge Tank. Pedras Dam Is at the Extreme Right

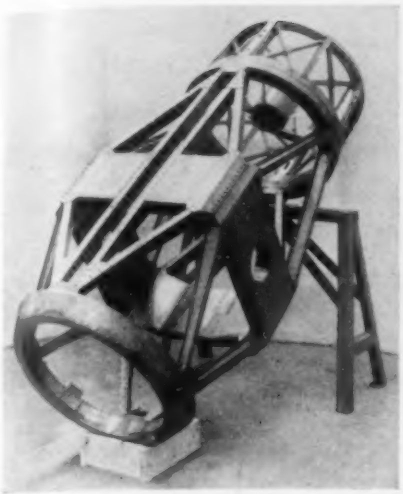


Fig. 3. The One-Tenth Scale Model Tube
This Model Is Now Set Up as a 20-In. Telescope

the 200-in. mirror at one end and various optical parts at the other. These parts consist of the plate holder with its Ross correcting lenses for work at the prime focus and three different convex mirrors for the other optical combinations. The focal ratios were established by optical considerations. However, the engineers have good cause to be thankful that the focal ratio (focal length divided by aperture) selected for the prime focus is unusually small. This made possible a comparatively short tube (55 ft), thus lessening the difficulty of securing adequate stiffness and also reducing the size of dome required. Fig. 2 shows the optical parts, the deflections permitted by optical considerations, and the calculated deflections for the actual tube as built. Except for a secondary effect at the coudé focus, there is no limit to the permissible amount of parallel deflection of the optical system as a whole. Stars are for all practical purposes at infinity; hence, any deflection or motion of the tube so long as it is parallel—that is, translation without rotation—has no effect on the images.

A photograph of the one-tenth scale model (Fig. 3) shows clearly the type of tube selected. The cage is shown bolted to the upper ring of the tube, and the small cylinder inside is the prime focus assembly which contains the convex mirrors and supports the plate holder. The cage was made removable because the diaphragms which support the prime focus assembly cause a diffraction pattern, and by rotating the cage this pattern can be shifted in direction.

The 200-in. mirror will be mounted on top of a table, bolted to the bottom of the ring at the lower end of the tube. This table is now part of the grinding machine.

The theory of this tube is indicated in Fig. 4(*a*). Considering the ideal case, the point A deflects normal to the axis of the tube a distance d_A, and the point B does likewise. By adjusting the area of the diagonals, point A and point B can be made to deflect the same amount. The diagonals in the top and bottom faces act as spacers to keep the end rings parallel with each other. Thus in the case of the ideal tube there is no relative deflection between the bottom ring and the top ring.

On the south face of the tube there is a slot 38 ft long, which is necessary in order to permit a light beam to reach the coudé focus in all positions of the telescope.

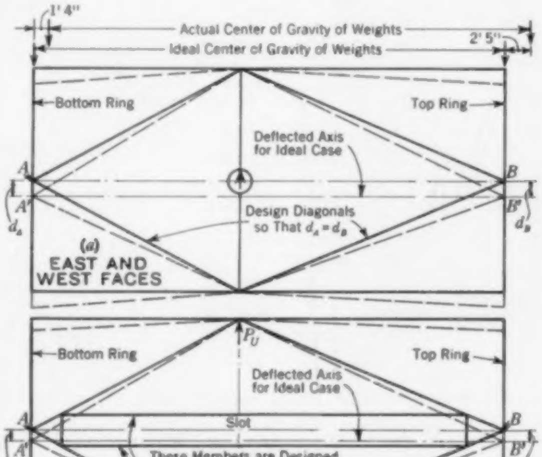


Fig. 4. Deflections of Tube

As shown in Fig. 4(*b*), this face of the tube deflects in exactly the same manner as the east and west faces when $P_U = P_L$. The deflection of the horseshoe makes the support for the lower declination bearing a little stiffer than that for the upper bearing; hence, the lower bearing will carry a little more load. Calculations and tests on the model indicate that the effect of the slot is well within the allowable limits. However, clamps are provided across the slot to eliminate this effect completely for work at the prime and cassegrain foci.

Because of the slot there is an unsymmetrical condition at the rectangular center section of the tube. If the center section had rigid corners, it would have a tendency to deform, when the telescope is turned 90 deg east, as indicated in Fig. 5(*a*). The force required to prevent this sideways movement was found to be quite large, and as this would have a tendency to make the upper end of the tube elliptical it was decided to make elastic hinges at the corners, as shown in Fig. 5(*b*).

The model was made accurately to scale and then tested for deflections. A system of mirrors was devised whereby deflections of approximately $^1/_{100,000}$ of an inch could be measured. These deflections gave a good check on the computed deflections. The model also gives a good idea of the assembly of the different shipping pieces. The cage is the largest, being 22 ft in diameter and 13 ft high. The I-beams are bolted at each end, and the rectangular center is bolted at its four corners. The individual pieces are made from plates welded together and stress-relieved before machining, the purpose of the stress-relieving being to reduce the possibility of warping during and after machining.

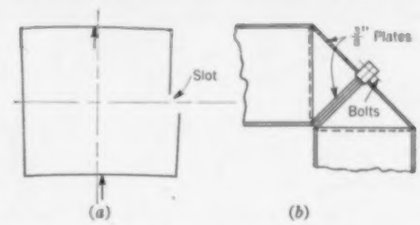


Fig. 5. Deformation of Center Section of Tube, Assuming Rigid Corners. At Right, Detail of Elastic Hinges

As illustrated by the model in Fig. 6, the yoke serves as a support for the tube. It is designed to permit the tube to be turned about the declination axis from the southern horizon to one degree below the north pole and to permit the telescope to be turned 105 deg each side of the zenith about the polar axis. It is therefore possible, by waiting until the proper time, to observe any star that shows above the horizon during the year.

The prime structural requirement is that the declination axis must, within narrow limits, remain perpendicular to the earth's polar axis as the telescope rotates. If this is not so, a component of rotation is added about the polar axis and declination axis, and to the stars about the optical axis of the tube. The first two of these are not serious because atmospheric refraction causes a similar effect, for which correction must be made; but rotation of the field is serious because it is very bothersome to correct by hand.

It is possible to eliminate this effect. The two deflections which must be considered in order to do so are the deflection of the horse-

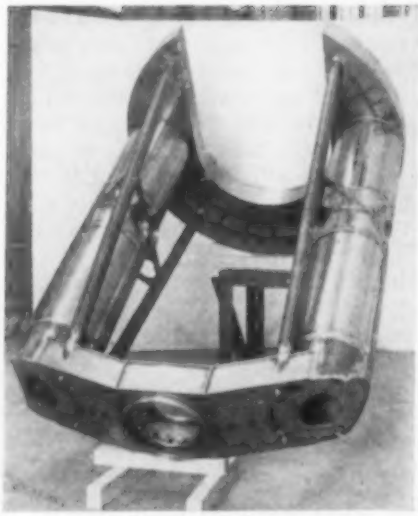


FIG. 6. THE ONE-TENTH SCALE MODEL YOKE

shoe and the deflection of the yoke. Consider, first, that a strut is placed across the horseshoe which will prevent it from deflecting as a hook. Then, from Fig. 7, it can be seen that by adjusting the relative stiffness of the south cross-piece and the horseshoe as a girder, we can make a yoke in which the declination axis remains at right angles to the polar axis. The change in this angle due to the deflection of the frame, if any, varies with the sine of the angle of rotation about the polar axis. It can be shown that by shifting the polar axis of the instrument a certain amount with respect to the polar axis of the earth, the declination axis will remain in a plane perpendicular to the earth's axis of rotation. This causes slight changes in the speed of

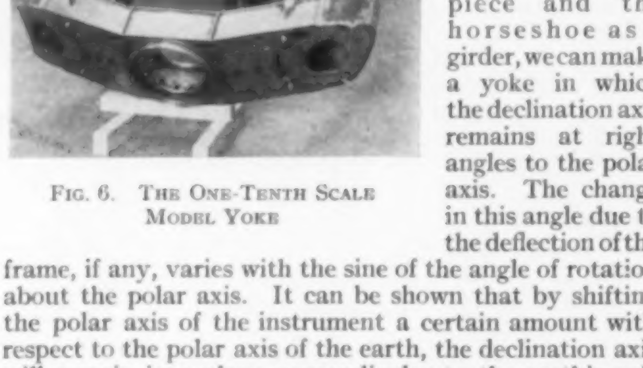


FIG. 7. DEFLECTIONS OF YOKE

rotation about the polar axis and declination axis which are not bothersome if small, but does not introduce rotation of the field.

As a check on the calculations, tests were made on the tenth-scale model. The results were not as close as had been hoped for, probably because of the difficulty of making the proper allowances for the corners and the involved nature of the calculations due to the horseshoe. Some changes were made in the final design of the yoke to compensate for these differences.

The upper polar bearing is made by supporting the horseshoe on oil pads, a pair on each side, as indicated in Fig. 8. These pads, which are 28 in. square, have babbitt faces with recesses to which oil will be pumped. The pressure will be adjusted so that metallic contact is eliminated and bearing friction reduced to a minimum. The deflections of the horseshoe thus cause changes in the instantaneous center of rotation of the upper bearing and a corresponding shift in the direction of the polar axis of the instrument.

As shown in Fig. 8, the horseshoe was machined in order to compensate as much as possible for the effect of these deflections; and Fig. 9 shows the horseshoe on the boring mill with the strut and tie in place. When the forces are released after machining, the horns will spring out, approximately as shown in Fig. 8. The point of application and magnitude of these forces was worked out by trial and error until a combination was found which gave the best results. It was not possible to shape the horseshoe so as to compensate within the allowable limits for the deflections in all positions. It was therefore decided to shape it so as to give the most perfect compensation when observing stars that are within 45 deg of the zenith. Most important astronomical work should be done in this area because atmospheric effects begin to increase rapidly as the stars get lower in the sky.

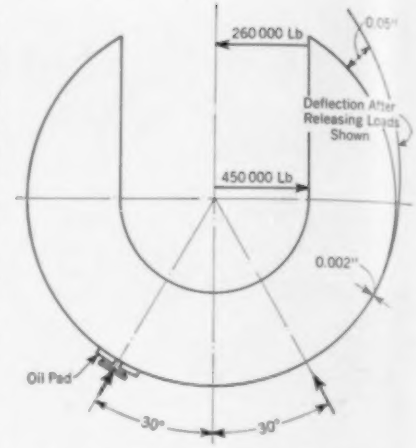


FIG. 8. HORSESHOE AND BEARINGS

The Loads Indicated Were Applied During the Machining to Compensate for Deflections That Will Be Produced When the Telescope Is in Operation

The side girders are pipes 10 ft 6 in. in diameter, made from 1-in. plate. This construction allows for an additional place where observations can be made. For instance, should a large cassegrain spectrograph be desired, then the cassegrain focus can, by adding a couple of flat mirrors, be brought through the declination axis and down on the axis of one of the side girders. There an instrument 12 ft long can be used. The 2-ft diameter pipes brace the horseshoe so that it stays more nearly in a plane as the yoke rotates and also stiffens the side girder as a beam by making the upper end nearly fixed-ended.

Like the tube, the parts of the yoke were built up from plates welded and stress-relieved. The photograph (Fig. 9) shows how the yoke is divided into shipping pieces. The horseshoe was made in three pieces, which are bolted together with internal flanged joints, each piece weighing about 52 tons. The 10-ft 6-in. diameter pipe-girders are divided into three sections—again with internal flange-bolted joints. A center section was provided, due to the machine work required at the support for the declination bearing. The south cross-piece is one shipping piece 46 ft long and weighing 45 tons.

FIG. 9. HORSESHOE ON BORING MILL AT PITTSBURGH; NOTE TENSION AND COMPRESSION DEVICES

The dome building, which is now nearing completion, has a large door to permit the pieces of the telescope to be brought inside. In the top of the dome a 60-ton crane has been installed for use in erecting the telescope.

The large pieces of the telescope are now nearing completion in the shop of the Westinghouse Electric and Manufacturing Company in Philadelphia. Westinghouse engineers contributed many ideas to the design; they also made an independent check on the deflections of the yoke, using a $^{1}/_{32}$-scale celluloid model. The design work was done by engineers working on the campus at the California Institute of Technology under the direction of Capt. C. S. McDowell, U. S. Navy, retired.

Present-Day Irrigation Methods in China

Many Primitive Devices Still Defy Economic Competition in the Orient

By O. J. Todd

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CHINA is as far removed from the Western world in its engineering technique as it is in physical distance. Economic conditions and the tremendous man-power available there make some of the primitive methods still in use as sensible as they were a thousand years ago. Native engineers, returning to China from the schools of the West, are teaching new methods of irrigation, but these innovations are still not feasible in many parts of the country. Thus in outlining present-day irrigation practices in China, Mr. Todd is also presenting a fascinating picture of age-old customs and methods. The article is abridged from his paper before the Irrigation Division at the 1938 Annual Convention of the Society.

THE poverty of the rural population of China and the slowness of the government to recognize the need for heavy expenditures for irrigation works, have conspired to keep the technique in this branch of engineering primitive in many respects. Only in very recent years have Western methods been adopted in bringing water to Chinese farms, and then the experiments have been restricted to a few projects of rather limited size. Even in these cases hand labor has played a most important role in the construction work, and the use of modern machinery has been held to a minimum.

So in discussing the methods used in China today for developing irrigation we must necessarily be reviewing much of the practice of the past—well-established practice that seems to have fitted into the economy of the country. It will be noted that deviations from such practice have been on a rather small scale and have not required very heavy capital outlays. Consideration of more thoroughly Western methods has flourished among the younger engineering graduates, but the actual raising of the sums of money required or the initiation of large projects that would run into as much as $1,000,000 (U. S.) apiece have not become matters of history. Nor can any immediate change in that direction be expected in view of the present upset political conditions that will impoverish the nation and make other very necessary outlays for human needs precede irrigation works in the national budget.

The modern trained engineers of China desire a break with the past and an adoption of the best Western practices in irrigation just as rapidly as they can convince their government that the results to be attained warrant the expenditures entailed. Most likely the experiments on small modern projects conducted during the past six to eight years in Shensi Province will do much as pioneer measures to produce the necessary change in outlook by those in political power.

In Civil Engineering for August 1937, I briefly sketched the work of the most recent irrigation practice in China in an article called "The Progress of Irrigation in North China." Short descriptions of four rather modern projects in northwestern China were given, indicating the nature and sizes of structures built, areas of the several districts served, financial outlays involved, and other features. In the present paper I shall tell something of the types of irrigation, ancient and modern, in use today in various parts of China, with some particulars as to the hand methods or native mechanical devices employed. Some of these devices are being supplanted, while others still defy competition under the present economic setup.

Of the various native methods of getting water on to the land, perhaps the bamboo wheel is the least efficient in use of power, but it costs little and is still used in remote western China from Lanchow in Kansu to the Indo-China border. The wheel is placed at the edge of a running stream, and the water in the channel diverted to operate it moves the paddles which alternate with the bamboo buckets that are placed on its periphery. These buckets are arranged at an angle, with one end of the bucket open, so as to allow dumping into a trough placed at one side near the top of the wheel. From this trough, which runs parallel to the plane of the wheel, another long trough leads away at an angle of 90 deg to the nearby lands to be watered. These wheels, which as a rule are from 20 to 50 ft in diameter, may be kept going constantly in irrigation season except during flood stages, when they must be removed to escape destruction. They are all "homemade" and readily repaired. For many centuries in South China this means of raising water for irrigation has been employed.

FORTY THOUSAND IRRIGATION WELLS IN ONE COUNTY

The "Persian wheel," with its endless chains with long, shallow buckets, more than a foot in spread between chains, is a far more reliable means of getting water to crops. It is extensively used in the northern provinces of Hopei, Shantung, Honan, Shansi, and Shensi where gravity irrigation by direct diversion from streams is not possible and good well water is available at reasonable depths. Probably Hopei, with its many wells along the Peking-Hankow Railway, uses this method of irrigation to the greatest advantage. A survey made in 1930 and 1931 under my direction for the Governor of Hopei, covered three counties in that province. In one of these, Ting Hsien, we found 40,000 wells for irrigation exclusive of those in the villages. These had been dug, for the

Terraced Szechuan Rice Fields Under Irrigation
Dragon Pumps Are Used When Water Must Be Raised

THE DRAGON PUMP IS USED THROUGHOUT CHINA

most part, since the beginning of the present century—25,000 of them between 1916 and 1931. This stimulus to modern well digging came partly from America after the severe drought famine of 1920–1921, when costs for the labor to construct many of the wells was contributed by relief agencies. The wells averaged 30 ft in depth and 6 ft in diameter, and the brick for curbing was furnished by the land owners. The cost per well was little over $15 (U. S.) for labor and a similar amount for curbing bricks and board bottom.

The water table may be anywhere from 15 to 40 ft below the ground surface. Most of the wells are so dug as to accumulate 5 to 6 ft of water during the night—a sufficient supply for the next day's irrigation. One such well in Hopei can serve about three acres of land where the water table is normal. Where the soil is not too tight and the inflow rapid, as much as 7 or 8 acres may be served from one well. A good pumping outfit of the Persian-wheel type costs from $30 to $50 (U. S.), and the cost for operation is light. The power is supplied by a donkey or cow hitched to a short sweep turning a large geared "bull-wheel," the cogs of which mesh with those of an upright wheel that turns the endless chains. Formerly these sets were made entirely of wood and produced locally. Now they are made of metal and sold at about the price of those made of wood alone.

HAND WINDLASSES, WEIGHTED POLES, AND DRAGON PUMPS

The hand windlass is used in the same regions that employ the Persian wheel. Those farmers who cannot afford the more expensive outfit for pumping, and have a surplus of human labor rather than of domestic animals, use a windlass costing about $3. In small wells one such windlass is enough, for a strong Chinese farmer makes good progress raising water 15 to 25 ft with a woven willow basket at the end of a rope, bringing up 5 gal at a time. Where the wells are larger two hand windlasses are used at once side by side. With a good shade tree or two planted close to the well, and the men stripped to the waist, this work does not seem too arduous especially when begun in the cool of the morning before sunrise. Farm labor in North China costs 15 cents per day, or even less where there are many sons in the family. Under these conditions this method of irrigation has much to recommend it as being economically sound.

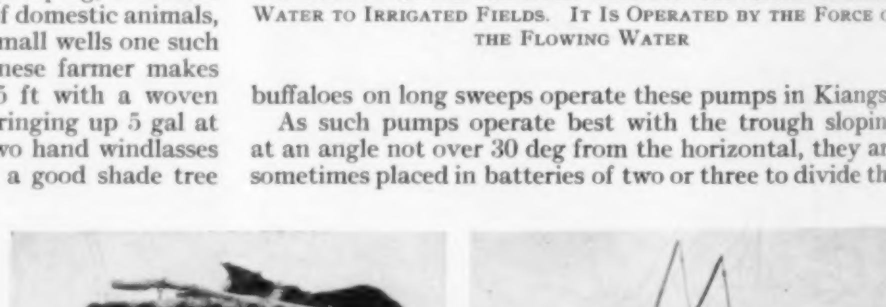
In Suiyuan Province one sees the weighted pole used over the curbed well to draw water up 10 to 15 ft for watering gardens, poppy fields, and even wheat. The pivot over which the weighted pole is swung is a short wooden axle fitted into holes in two stone posts spaced 2 to 3 ft apart and back a few feet from the well's edge. The bucket is attached to the short and heavier end of the pole by 10 to 15 ft of rope, and a stone is attached to the long end of the pole to help raise the bucket when full. So the operating farmer uses about the same energy to force the empty bucket down into the well as he does to help raise it when filled. Five gallons or more are brought up per trip by means of this device—the same quantity as with the hand windlass, and the work seems easier. The cost for the pole or sweep, the pivot, and the two stone posts in place should not exceed $10.

In the Yangtze region the dragon pump, or *shui lung*, is used extensively. It consists of a wooden rectangular trough 12 to 16 ft long, as a rule, and about 1 ft wide, with an endless chain of wooden paddles that just miss touching its sides. The paddlechain passes around a sprocket wheel fastened to the rotating axis where power is applied. The power may be human or animal or even steam, as in the case of one rather modern farm near Tientsin where a battery of such pumps was attached to a long axis that was engine-driven. Human beings operating treadmills, and holding onto a bar that helps them stand erect, seem to have the monopoly on operating the dragon pumps along the Yangtze. Water

THE BAMBOO WHEEL HAS BEEN USED FOR CENTURIES TO RAISE WATER TO IRRIGATED FIELDS. IT IS OPERATED BY THE FORCE OF THE FLOWING WATER

buffaloes on long sweeps operate these pumps in Kiangsi.

As such pumps operate best with the trough sloping at an angle not over 30 deg from the horizontal, they are sometimes placed in batteries of two or three to divide the



FOR ECONOMIC REASONS THE PERSIAN WHEEL AND THE WEIGHTED POLE STILL HOLD THEIR OWN AGAINST MORE MODERN PUMPING METHODS

lift. Troughs 20 ft or more in length are rare. Good local carpenters can make a 14- or 15-ft unit for less than $10, the cost including both lumber and labor.

Where the water in a canal or stream is within 4 to 6 ft of a field, the willow basket operated by two men with ropes is frequently used to throw the water up this additional height. A piece of bamboo or reed matting is usually placed at the stream edge of the field to prevent wash and direct the water into the irrigation ditch. The men stand 10 to 12 ft apart on opposite sides of a sump dug at the side of the stream and handle a light rope in each hand attached to the sides of the basin-shaped basket. Dipping and dumping are thus done rhythmically and rather effectively. At times fields are irrigated by raising water up two such levels of 4 or 5 ft each. This type of irrigation is found in many parts of North and Central China. Where the lift is only 2 or 3 ft this device is frequently employed also to unwater pools on construction work.

LARGER IRRIGATION PROJECTS SERVED BY GRAVITY

The larger irrigation projects of China are served by gravity systems, river water being diverted directly from the stream with or without the aid of a diversion dam. In the cases of all irrigation from the Yellow River no diversion dams are employed. The water is taken into the canal systems when the river is at high stages (summer and autumn). This is true around Ningsia, in the Haotao region, at Saratsi, and with the Mongol canals near Tokoto. The same system was employed at times on the Fen Ho in the Taiyuan Valley except in low-water stages, when earth dams were constructed across the river and all the water was saved for the lands. These earth dams were permitted to remain for a certain number of days only. Then each in turn was broken to release the water to another dam a few miles downstream to feed another set of canals, a zoning system having been agreed upon for the whole Taiyuan Valley. Now three masonry dams or gate structures do the work of 11 of those temporary earth dams of former years.

A TEMPORARY DAM ON THE FEN-HO, INSTALLED DURING THE LOW-WATER SEASON TO FEED THE TUNG-LI CANAL

The most famous of China's irrigation projects is that near Chengtu, Szechuan. It is many centuries old and is fed by the Min River, which is turned through a cut in the rocks to supply a system of canals controlled by native stoplog gates. On the plains watered by this system nearly 6,000,000 people live safely while their rice and other crops are guaranteed by the irrigation. In Shensi, the Wei Pei, Lo Ho, Wei Ho, and Mei Hwei projects are similar in that they are canal systems fed by diversions by low dams from the supplying rivers.

EXCAVATION IN THE "WET STRETCH" OF THE MAIN CANAL OF THE SARATSI PROJECT, IN SUIYUAN

These projects are the most desirable and economical, when the original cost can be charged over a series of years. The water rates are usually light (about $1 per acre per year), and the provincial authorities, with national or foreign relief aid, have stood back of the work to a certain extent and given it their blessing. The pioneering in these developments, however, has often been greatly aided and stimulated by men outside the province concerned, as they have been able to bring in the greatly needed funds. Most of the recent development of modern irrigation works is the by-product of relief work after drought famines.

In very recent years many kerosene engines operating centrifugal pumps have been installed in the Yangtze delta to replace dragon pumps and coolies. Where lands are very valuable these installations are said to be warranted. Their popularity will depend on operating costs, and it is questionable whether they can compete with coolie labor at 15 to 20 cents per day. In unwatering canals during excavation in Suiyuan in 1931 such engine-driven pumps were found to be considerably more expensive, on lifts up to 8 ft, than coolie labor bailing with 5-gal kerosene cans and passing water up in two steps of 4 ft each. This test was made, however, where labor was cheap and fuel costs high. Near Shanghai the relation is somewhat reversed.

During the past ten years, three steam-operated pumping plants have been installed close to the Fen Ho in Shansi to lift water a height of 15 to 20 ft into canals for irrigating cotton lands. However, various difficulties have overtaken these projects. Farmers have refused to pay the water taxes, saying they did not need the service except in dry years or when rainfall was not well distributed. Floods have injured the plants because of insufficient river training. Provincial officials have been indifferent. Incompetent men have been placed in charge of valuable equipment, and boilers have been burned out. In short, Shansi does not seem ready for such improvements, although without them the lands dependent upon irrigation will not produce crops in dry years. The people as a whole are still fatalists and dry farmers.

STORAGE OF FLOOD WATERS IMPRACTICABLE

The silt in the rivers of North China makes storage of flood waters impracticable. Reservoirs would be rapidly filled by such waters as those of the Fen Ho in the summer months when it carries solids up to 23 per cent by weight. The King Ho in Shensi in flood carries as high

as 50 per cent silt by weight at the intake of the Wei Pei irrigation project. No storage is possible there. Similarly the main Yellow River near Loyang, Honan, in August 1933, had a silt content of more than 40 per cent.

A "Two-Basket Man" with His 120-Lb Load

In some cases, such as the upper Fen Ho, the winter flow may have a silt content less than 1 per cent, and might safely be stored in reservoirs built with ample gates to pass flood waters. This clear water could be released during the spring months to supplement the ordinary river flow in aid of downstream irrigation. While such storage seems practical, no large reservoirs of this sort have been constructed. In fact, there are no irrigation storage reservoirs of consequence in China.

In southwestern Shansi there are possibilities for high-lift pumping to irrigate nearly 300,000 acres of good cotton land at an elevation of approximately 250 ft above the Yellow River. In case cheap hydroelectric power should be developed at the Hu-kou Falls, 50 miles north, it is possible that such high pumping might be economically feasible. As yet, however, China has not gone in for high-lift pumping to extend irrigation, and it may be many years before such developments take place.

One of the latest innovations in irrigation practice in China—siphoning—has been tried along the Yellow River in Honan and Shantung provinces within the past five years. It is connected with land reclamation as silt-laden water is desired to cover alkali lands, particularly in eastern Shantung near the mouth of the Yellow River. A small priming unit is maintained on the dike where two parallel iron pipes 24 in. in diameter are laid. With the valves on the land side closed, all air is readily removed from the siphon pipes after lowering intake ends into the river. These devices are of German manufacture and seem to work well, though the quantity of water thus handled is small.

Up to the present, cheap hand labor has played a large part in all irrigation development in China. It has made possible the building of a number of projects at a total cost of \$5 to \$6 per acre of land to be served. Wherever the cost has run as high as \$10 per acre, as with some of the pumping plants in Shansi, the farmers have objected to the tax of \$1 per acre per year for operation and retiring the original loan for plant.

HAND LABOR IN CONSTRUCTION

To the Westerner the most interesting feature of Chinese construction methods is the use of hand labor in quantity to handle excavation work. In North China in recent years hundreds of miles of canals have been dug by hand, using the old-fashioned basket method. One workman has two rather flat woven willow baskets suspended by four light ropes from the two ends of his carry pole. Into each basket he loads approximately 60 lb of earth and walks out of the canal to the dump with this load of 120 lb. Working steadily for 10 hours, he moves 4 cu yd, at an average carry of 100 ft, if the digging is in good ground and the depth moderate. His earning will be 15 to 20 cents for this task. All such work is done on the piece basis except in very wet soil or where there is drilling in cemented material. In cases where sand is encountered a large, deep basket, carried by two men by means of a heavy pole put under the handle, is used. This way of moving earth is less popular than by the single-man two-basket method. Nor is the wheelbarrow preferred as a rule.

In deep-cut excavation the two-basket man carries his load up a long earth ramp or up a set of steps he has carefully cut in the earth along the side of the canal. In still deeper cuts the tripod with pulley is used, and men in the bottom of the canal pull the rope that hoists a basket loaded with 60 lb of soil. This is, of course, an expensive way of earth moving, yet it fits into Chinese economy. By this method earth can be taken from a cut 40 ft deep at 10 cents per cu yd.

Quarrying of rock and placing it in structures is all done by hand in China, as is the mixing and placing of concrete. The wheelbarrow and shovel are the chief tools required. Everywhere man-power sets the pace for the work to be done.

It is interesting to the Western engineer that the Chinese like tunneling. They do not hesitate to tackle long tunnels through the fairly easily worked limestone hills of Shansi in order to bring water from one valley to another where it is more needed for irrigation. Infinite patience and low wages make these things economically sound in China in cases where they would not be so considered in the West.

So China moves along, showing some development and a willingness to make comparisons between Western practice and her own old ways. But in most of these experiments with the more modern practice of the West, China continues to lean strongly on the brawn of her hard-working sons, who charge but 15 to 20 cents a day for their services—for she knows that high-priced machinery has to be paid for in real money, and so does fuel oil or gasoline. She knows that canals can be cleaned by hand today almost as cheaply as they could centuries ago. She knows that she is long on man-power, and that it has to be fed and therefore must be employed wherever possible. So her technique in irrigation extension is bound up closely with her population problem; the modernizing of the one will perhaps go along with the solving of the other. Modern pumps will be slow coming into China, and storage reservoirs will be very rare in North China until soil-erosion control is well in hand. And such progress in irrigation development as there has been in the past ten years may be considered very satisfactory by those who realize how little China has with which to pay for anything except her own native labor.

The Stone "Flapper" Is Used to Compact the Fill in River or Canal Dikes

To sense a situation where man-power is predominant one would have to watch eight coolies throw a stone "flapper" in the air 8 ft high or more and bring it down on a dike that needs packing. The ease and precision with which this 90-lb stone is thrown and then brought down with a swift draw on the ropes, which makes it strike the earth perfectly, reminds us that patience and brawn have built China's utilities in the past and are still at work. As economical working units men still underbid mules on irrigation work.

Structural Aspects of WGY'S 625-Ft Vertical Radiator

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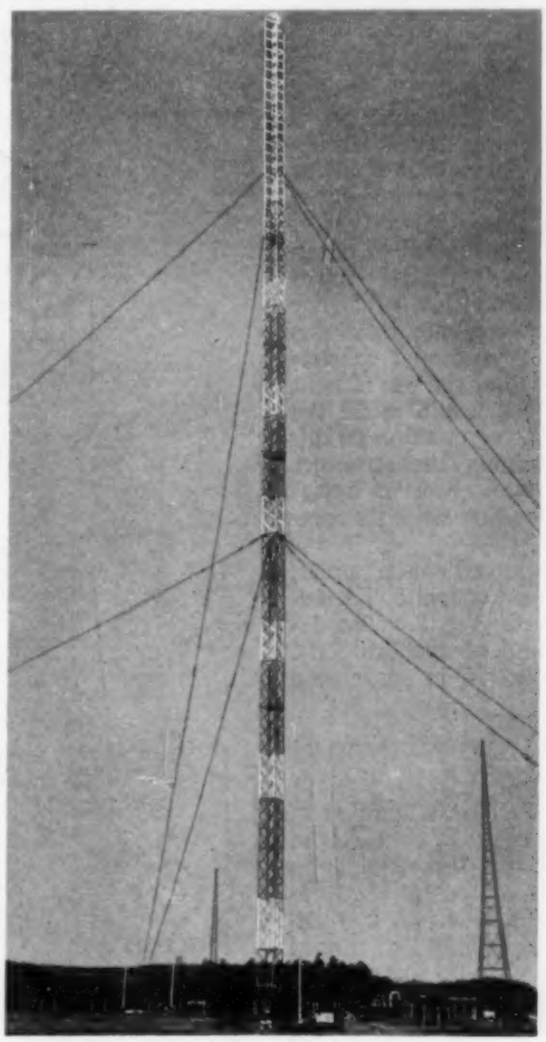
A STEEL antenna tower taller than the Washington Monument, yet resting on a single porcelain insulator 20 in. in diameter, was put in service on May 14, 1938, by WGY. Interesting features of its design and construction, and of the tests made on various structural elements, are sketched briefly here.

To improve and enlarge the broadcasting service of radio station WGY, a new vertical antenna, or "radiator," has been installed at South Schenectady, N.Y., where in 1922 the first facilities for sending out the call letters WGY were put into operation. The new tower greatly increases signal strength and extends the station's coverage area many miles, though no change has been made in the power output, and reception of programs from other stations is not blanketed.

Electrically, the ideal antenna would be a single, unsupported, vertical wire. The type of structure selected—a mast, with insulators inserted in series in the guys and at the tower base to keep the electrical losses within bounds—is the nearest feasible approach to this ideal from a structural standpoint.

The tower is 625 ft high, and 9 ft square for the full height, with the exception of the first section above the base, which is an inverted frustum of a pyramid. As shown by Fig. 1, the tower is supported at its base by a single porcelain base insulator; stability is provided by two sets of guys, four in each set, attached to the tower at the 250-ft and 500-ft levels, respectively, and anchored to concrete deadmen. For electrical reasons, the continuity of the guys is broken by compression-type porcelain insulators located at progressively increasing distances from the tower.

This radiator may be considered a "middle-of-the-road" type, not being as light as some of the strictly competitive towers nor as heavy as the towers for this class of work designed by the various U. S. Government departments. The weight of the steel in the tower and deadmen is approximately 75 tons; the guys with their fittings weigh about 23 tons; and the insulator assemblies weigh about 16.5 tons. Specifications covering the general design, materials, and erection were drawn up by the Construction Engineering Department of the General Electric Company, while design and details were left to the tower fabricators.



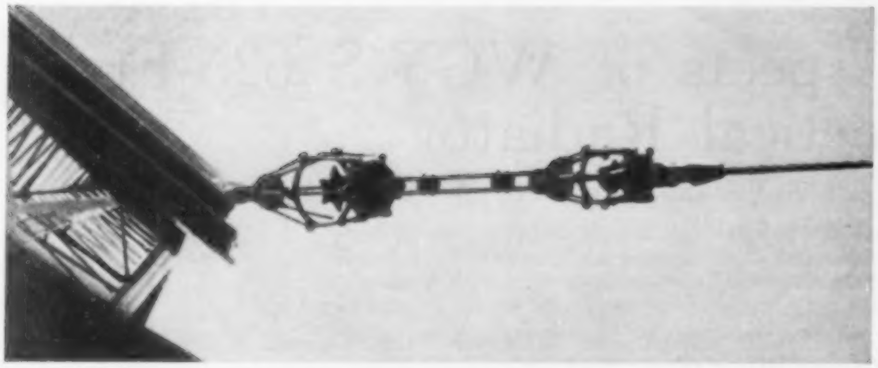
The New Radiator at South Schenectady—Tall as a 50-Story Building

The tower was designed as a continuous structure, the wind load being assumed unidirectional only. The structure is provided with sufficient cross-bracing to hold its shape, although no particular provisions for torsional stresses were made. The framing consists of four corner angles varying in size from 8 by 8 in. to 4 by 4 in., and the web system is of the double-intersection type with struts at suitable intervals. Cross-bracing in horizontal planes also is provided.

The loads assumed for the design are as follows: (1) dead load; (2) wind load (25 lb per sq ft for the lower 300 ft and 35 lb per sq ft for the upper 325 ft); (3) load due to a $^1/_2$-in. coating of ice over the entire structure, including the guys and insulators; (4) load imposed by a temperature variation of 80 deg F; (5) load incident to an attached illuminated display sign. The specified wind loads were applied to 150 per cent of the projected area of the tower, with the wind assumed to be blowing horizontally in any direction. The tower was assumed loaded either on the diagonal or on faces normal to the wind. Such direction of wind load was assumed as would produce maximum stress in the tower members or guys under consideration. No reduction in wind pressure was assumed due to sloping surfaces or to "kissing off" of the wind.

MAXIMUM STRESSES

Under most unfavorable combinations of structure loading, the following unit stresses are not exceeded: (1) axial tension on net sections, 20,000 lb per sq in.; (2) axial compression on gross section, 20,000–85 L/R lb per sq in.; (3) maximum compression, 15,000 lb per sq in.; (4) shear on bolts, 13,500 lb per sq in.; and (5) bearing on bolts, 27,000 lb per sq in. Combined axial and bending stresses do not exceed the values listed in items 1, 2, and 3, and unit stresses through roots of threads



Looking Up at One of the Insulators

of bolts and in material at or near the ground surface do not exceed 75 per cent of the values stated. The maximum slenderness ratios for the main legs, web members, and redundant members are 120, 150, and 200, respectively.

Under maximum guy stress the factor of safety will be in excess of 3.5. The upper guys have a maximum stress of 100,000 lb, and the lower guys a maximum of 80,000 lb. The guys are of galvanized wire rope, consisting of 6 strands of 19 wires each plus an independent wire-rope center consisting of 7 strands of 7 wires each. The upper guy ropes are $2^1/_8$ in. in diameter; the lower ones, $1^7/_8$ in. Rope and bridge sockets provide the connections to guy insulators and deadmen, respectively. Zinc is used for embedding the wires in the sockets. The lower guys were provided with an initial stress of 40,000 lb, and the upper guys of 50,000 lb.

The tower wind loading, although seemingly high, is known to be moderate; many structures have been designed with an assumed wind load above that used for this structure. The maximum stresses were calculated on the basis of the most unfavorable combination of loading and temperature, since it was desired to eliminate the possibility of overloading any part of the tower or its accessories. Secondary stresses due to faulty tower details were avoided as far as the economics of this type of structure justified. The tower proper consists of conventional structural elements, and the use of bent or otherwise deformed members that would make the stresses uncertain was avoided. During erection no difficulty was experienced in maintaining the structure square and plumb; and the maximum observed deviation in vertical plane under wind loading since its completion is less than one inch.

The base insulator rests on a reinforced concrete pier, and the deadmen are also of reinforced concrete. A section through the deadmen is shown in Fig. 2. The details of their design and the method of anchoring the ropes is typical of the practice followed in suspension bridges.

Foundations and Structural Elements Carefully Investigated

To guide the design of the foundations, a number of tests were undertaken to determine both the character of the soil and its load-bearing capacity. Four test holes were put down about 400 ft from the tower, at the locations originally planned for the deadmen. A conventional well-drilling rig was used, and drilling was carried sufficiently far to assure that there were no soft pockets at the foundation sites. Rock was encountered at an average depth of about 27 ft, and though the drilling was done in April, when ground water is high in this locality, practically no water was encountered above the rock surface. The drill samples indicated a varying type of soil; sand, clay, a small amount of gravel, and boulders were found.

At the pier site, the soil 10 ft below the ground surface was tested for load-bearing capacity. A 4-sq ft wooden test platform, with the conventional type of mast and loading platform, was used. The behavior of the soil under the test loads was observed with a wye level, and also with a multiplication lever having a ratio of 5:1. The lever fulcrum was attached to a board projecting from the timber sheathing that held the ground in place around the center pier. To this board, a sheet of white paper was attached, on which was traced the position of the lever at the time of inspection. The soil action under

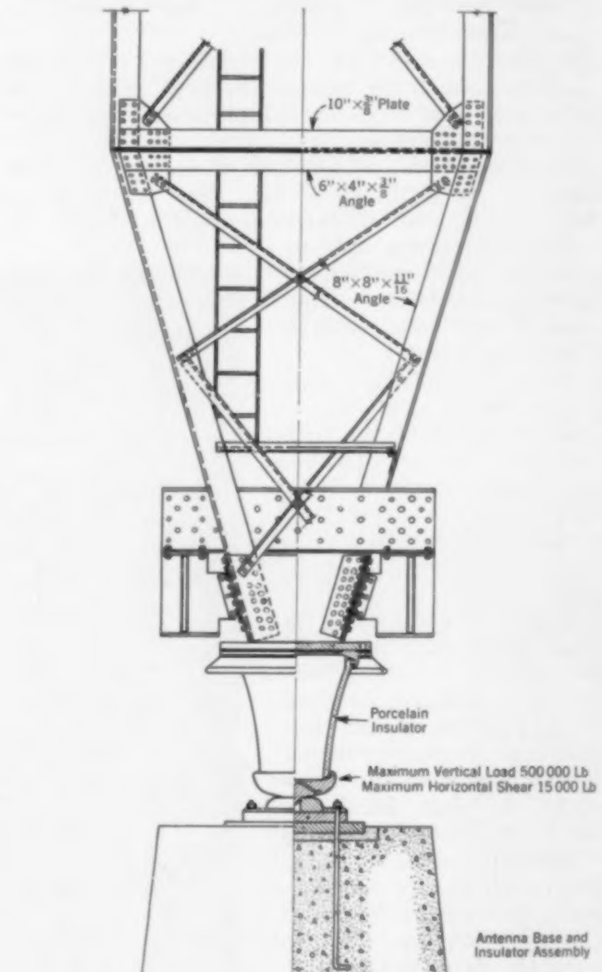
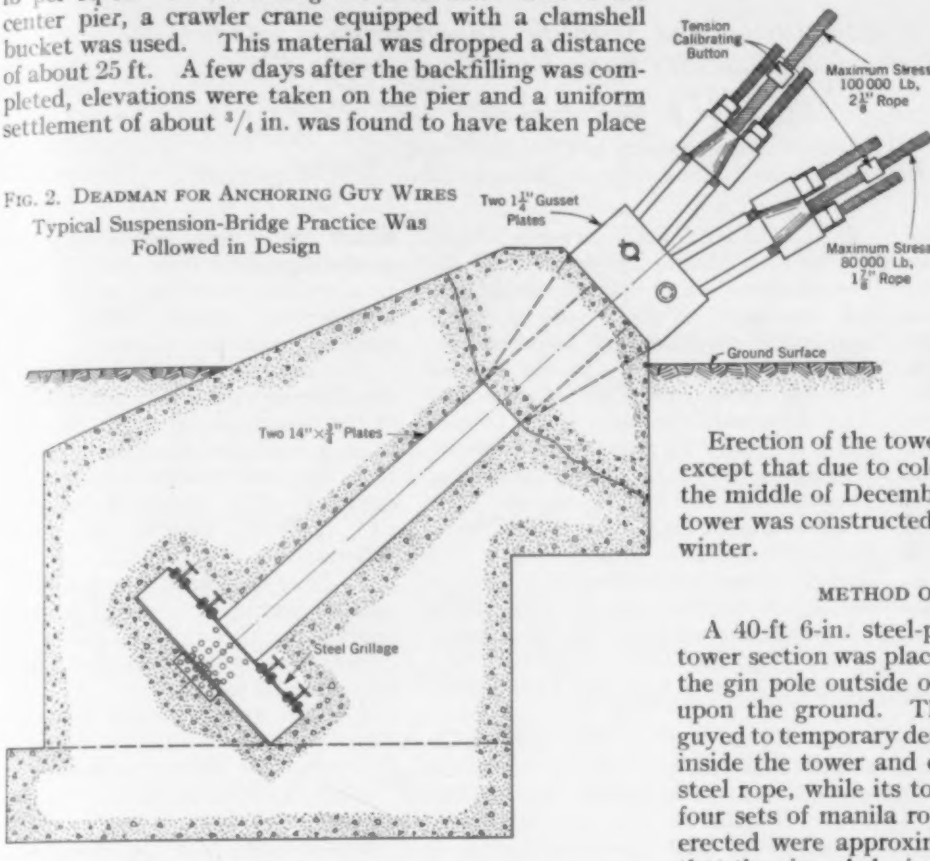


Fig. 1. Antenna Base and Foundation

the successive increments of test loading is indicated in Fig. 3.

The maximum computed soil bearing is about 3,500 lb per sq ft. In backfilling the excavation around the center pier, a crawler crane equipped with a clamshell bucket was used. This material was dropped a distance of about 25 ft. A few days after the backfilling was completed, elevations were taken on the pier and a uniform settlement of about $^3/_4$ in. was found to have taken place

FIG. 2. DEADMAN FOR ANCHORING GUY WIRES
Typical Suspension-Bridge Practice Was Followed in Design



as the result of the consolidation caused by the dropping of the backfill. The total settlement from the date that steel erection was begun until the structure was completed, and the guys were properly tensioned, was one inch.

An extensive program of testing was undertaken during and after fabrication of the various elements. A sufficient number of fittings, guy ropes, and insulators were tested to destruction to determine their ultimate strengths. All guy assemblies, insulators, and fittings were proof-tested 40 per cent in excess of the expected maximum stress, except the base insulator, which was proof-tested 60 per cent in excess of the maximum load.

All ropes were proof-tested to 125,000 and 100,000 lb for the $2^1/_8$-in. and the $1^7/_8$-in. ropes, respectively. In addition, two pieces of each size of guy rope, 15 ft long, were tested to destruction. At one end of the test specimen regular sockets were cast in place, and for convenience in use in the testing machine, a special fitting was used at the other end. All specimens broke in the rope about 1 ft from the fittings. Individual wires showed good reduction of area and clean cup-type breaks.

For stress-measuring purposes in the field, the guy rope sections adjacent to the deadmen were provided with zinc buttons scribed 100 in. apart.

The construction of the guy insulators is shown in an accompanying photograph. One guy insulator assembly, tested to destruction, developed a strength of 429,400 lb, and another tested 385,400 lb. Two others were tested to 350,000 lb, the nominal ultimate rating, at which value the tests were discontinued. This is $3^1/_2$ times the maximum working load.

It will be noted in the photograph that six rods carry the stresses from the guys to a base ring supporting the insulator porcelain. Ordinarily multiple-stress paths provide uncertainty as to stress distribution. However, the distribution of stress in these units, as far as visual inspection allowed it to be observed, was entirely satisfactory. In no instance were the rods the limiting strength factor. When the rods broke, the failure of the porcelain preceded it as nearly as could be determined.

A duplicate of the base insulator was tested to destruction in the 10,000,000-lb testing machine of the Bureau of Standards at Washington, D.C. The breaking load was more than $4^1/_2$ times the designed working load of 475,000 lb.

Erection of the tower involved no particular difficulties except that due to cold and inclement weather. Started the middle of December and completed by March 1, the tower was constructed during the most severe part of the winter.

METHOD OF ERECTION OF TOWER

A 40-ft 6-in. steel-pipe gin pole was used. The first tower section was placed in position on the insulator with the gin pole outside of the tower, resting on sills placed upon the ground. This section of the tower was then guyed to temporary deadmen; and the gin pole was placed inside the tower and cradled to the tower columns with steel rope, while its top was guyed to the columns with four sets of manila rope in multiple falls. The sections erected were approximately 25 ft long, which required that the gin pole be jumped for each 25-ft rise of the tower.

All connections were bolted with $^3/_4$-in. bolts except at the bends of the first section, where the transition from the pyramid to the square required that the column angles be bent. This joint was shop-welded.

The steel members of the tower were galvanized at the plant, but the tower was painted after erection with alternating stripes of international orange and white to comply with the requirements of the Aeronautical Division of the Department of Commerce. The galvanizing was applied to improve conductivity and to prevent oxidation of the parts in contact. Guys, guy fittings, and the embedded anchorage steel were also galvanized.

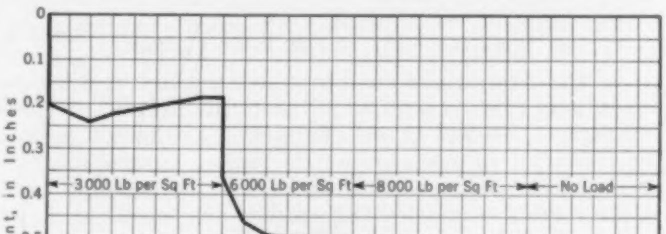


FIG. 3. RESULTS OF SOIL BEARING TEST AT FOUNDATION SITE
Loads Were Applied to a 2-Ft by 2-Ft Bearing Mat 10 Ft Below Ground Surface

Tax Structure Analysis for Highway Planning

Levies in Accordance with Benefits and Scientific Apportioning of Funds to the Various Highway Systems Are Basic Features of Oregon Plan

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FUNDAMENTAL among highway planning problems is the formulation of an equitable and adequate tax structure. Without such a basis, long-range programming becomes conjectural and insecure. In the accompanying article, Dr. McCullough outlines the method developed by the Oregon State Highway Department for apportioning highway taxes among the various beneficiaries—the road users, the community, and the land—and for distributing the available funds among the several types of highways to insure maximum benefit returns. The article is abridged from a paper on the program of the Highway Division at the 1938 Annual Convention in Salt Lake City.

DEVELOPMENT of any state-wide highway taxing plan immediately opens up several basic fields of inquiry. Principal among these are (1) determination of the percentage of cost for each system of roads or streets within the state-wide network that should be carried by each of the beneficiaries thereof; and (2) determination of the percentage of funds from each of the various sources of revenue that should be allocated to each of the various street and road systems.

Several theories have been advanced for the apportionment of highway costs and the allocation of highway funds. One of these utilizes as a criterion a comparison of per capita road-cost values before and after the advent of automotive transport. Other theories find their bases in mileage costs and quantitative road use. It is the opinion of the writer that none of these will stand up under searching scrutiny. Benefits constitute the quid pro quo for taxation, it being a well-settled rule of law that "where there is no benefit, there is no power to tax." Imposts, therefore, should be assessed and collected on the basis of benefits and benefits alone; and as a necessary and inevitable corollary, the funds should be expended where the maximum benefits can be produced.

The application of these benefit criteria to any state-wide network of roads or streets necessitates (1) a division of the entire network into suitable component systems; (2) a determination of the beneficiaries of each system; (3) an evaluation of the benefits accruing; and (4) a segregation or distribution of these benefits to each of the beneficiary groups involved. Each of these phases will be considered in turn.

THE GROUPING OF THE ROAD SYSTEMS

In the grouping of road systems, the first distinction to present itself is a broad division into urban and rural transportation ways; and the second distinction is that of character of use—as arterial ways, general-use laterals, and special-service ways. In accordance with these classifications, the Oregon network was divided and grouped as follows:

- System R-1—Rural arterials (6,205 miles)
- System R-2—Rural general-use laterals (3,363 miles)
- System R-3—Rural land-service ways (39,667 miles)
- System U-1—Urban arterials (347 miles)
- System U-2—Urban general-use laterals (728 miles)
- System U-3—Urban land-service ways (1,977 miles)

The R-1 system comprehends all roads now designated as state highways, together with their extensions through national forests, parks, and reservations. The R-2 system comprehends those rural laterals or feeder roads which are general-use in character as distinguished from the R-3 system, which is composed of special- or land-service roads. The urban classifications are parallel.

The next step in the procedure is the determination and enumeration of the beneficiary groups. Actually these groups are many, and the various interrelationships exceedingly complex. The principal beneficiaries, however, may be grouped as follows:

1. *The road user*, because of decreased vehicular operating costs, savings in time of operation, increased riding comfort and safety, and other factors.

2. *The general public* embraced within the state, county, or other political subdivision because of decreased commodity costs, promotion of public health, better police facilities, improved fire protection, and such other incidental but distinctly existent benefits as may be grouped under the classification of public welfare. These benefits accrue alike to all members of the community embraced within their scope, regardless of motor-vechicle ownership.

3. *Abutting and/or adjacent property* because of certain special benefits accruing thereto over and above general community benefits. A certain portion of these benefits, such as intrinsic enhancement in the value of abutting or adjacent property, are entirely independent of road use, while certain other special benefits are related to and grow out of road use but constitute a special, as distinguished from a general, use.

EVALUATION OF HIGHWAY BENEFITS

For the present purpose, all those benefits that grow out of the creation and development of highways may be broadly grouped under (1) motorized-transport benefits, and (2) residual benefits. Motorized-transport benefits may in turn be broken down into the "mileage group," embracing those functions of vehicular operating costs which vary with the mileage traveled; and the "time-element group," embracing functions of the time of operation. The mileage group is derived principally from a reduction in distance between termini; an improvement in roadway surface; a reduction in rise and fall; an improvement in gradients; an improved alignment; and elimination of traffic stops and congestion.

Methods have been worked out for evaluating benefits from each of these sources. For example, the annual benefits accruing from a reduction in distance between termini can be computed from the "mileage-element operating cost" data of Fig. 1, if the amount and character of the traffic are known. Again, the Oregon department has developed certain "roadway surface coefficients" which can be applied to the operating costs of

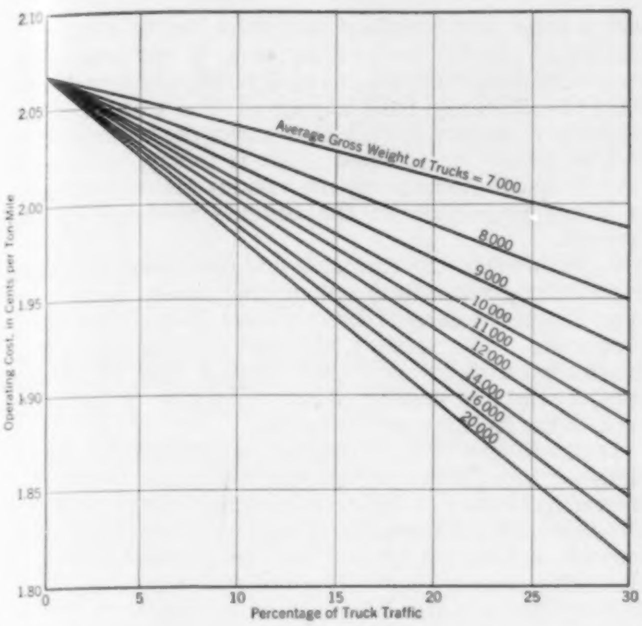

FIG. 1. COMBINED PASSENGER AND TRUCK MILEAGE-ELEMENT OPERATING COSTS

Fig. 1 to derive the benefits per ton-mile accruing to traffic by virtue of any improvement in roadway surfaces. The average values of these coefficients are as follows:

Unimproved earth	0.28
Loose gravel	0.19
Light oil treatment	0.03
Bituminous and portland cement concrete	0.00

and the benefits from any given roadway-surface improvement can be calculated from $S_s = LT_a c_m c_s$, where S_s is the annual benefit in dollars; L, the length of the route in miles; T_a, the annual traffic in tons; c_m, the unit mileage-element operating cost in dollars per ton-mile (from Fig. 1); and c_s, the decrease in roadway-surface coefficients.

Similar formulas were developed for the effect of reduction in rise and fall, improvement in gradients and alinements, and elimination of traffic stops; and for the various time-element benefits. Utilizing these formulas, the benefits per ton-mile accruing to traffic over each of the six highway systems in Oregon were calculated by the simple expedient of comparing the corresponding index values before and after the improvement of the various component roads. The results for the six systems are indicated in Table I.

Gradient effects and the effect of eliminating traffic stops were not included, as the resulting values were small. It will be observed that the unit benefits on the arterials were considerably higher than for the secondary and tertiary systems; also that rural traffic has benefited to a considerably greater extent than that over urban streets. This is due, not only to the higher standard of present improvement, but also to the fact that the rural roads, particularly the arterials, in Oregon, were in much worse condition prior to the advent of motorized transport than the other systems of the network.

Having determined the unit benefits for each of the component systems, the next step is to apply these data

TABLE II. ROAD USE AND ANNUAL MOTOR-TRANSPORT BENEFITS IN OREGON

System	Annual Road Use, in Ton-Miles	Annual Benefits
R-1	2,803,961,000	$99,054,000
R-2	422,478,000	5,191,000
R-3	188,073,000	1,703,000
U-1	867,849,000	8,668,000
U-2	577,842,000	3,135,000
U-3	390,168,000	1,784,000
	Total	$119,535,000

to road-use statistics. A summary of the results is presented in Table II. These are the benefits to motorized transport that the Oregon network delivers annually. It only remains to distribute them to the various beneficiary groups.

DISTRIBUTION OF BENEFITS TO MOTORIZED TRANSPORT

The following quotation from Bulletin No. 7 of the Oregon State Highway Department is pertinent in this connection:

"If motor vehicles were restricted to private passenger cars used exclusively for the owner's convenience, there would be few transmitted benefits. Such a restriction, however, does not exist. The highways throng with trucks transporting produce and manufactured articles. Regular bus service creates expeditious and economical transportation for the individual. Police cars, ambulances, fire-fighting equipment and patrols utilize the highways to increase many fold the efficacy of their service. The sphere of health conservation is augmented by bringing nearer to the individual the doctor, the veterinarian, and the nurse. Rural school buses render feasible the construction of consolidated schools with consequent improved educational facilities. These are only a few of the transportation benefits which are passed from the motor-vehicle operator to the community at large. They are enjoyed by the non-car owner in equal degree

TABLE I. AVERAGE TRANSPORTATION BENEFITS PER TON-MILE OF TRAFFIC

Passenger Vehicles

Benefit Factor	Average Value of Unit Benefit (Dollars per Ton-Mile) on System					
	R-1	R-2	R-3	U-1	U-2	U-3
Distance savings	0.00286	0.00057	0.00034	0.00062	...	...
Roadway-surface improvements	0.00352	0.00159	0.00045	0.00331	0.00166	0.00166
Elimination of rise and fall	0.00003	0.00002	...	...	...	...
Alinement improvements	0.00060	0.00028	0.00011	0.00010	...	...
Total mileage-element savings	0.00701	0.00246	0.00090	0.00403	0.00166	0.00166
Time-element savings	0.03311	0.01166	0.01062	0.00662	0.00441	0.00355
Grand total of unit-traffic benefits	0.04012	0.01412	0.01152	0.01065	0.00607	0.00521

Trucks and Buses

Benefit Factor	Average Value of Unit Benefit (Dollars per Ton-Mile) on System					
	R-1	R-2	R-3	U-1	U-2	U-3
Distance savings	0.00204	0.00041	0.00024	0.00044	...	...
Roadway-surface improvements	0.00252	0.00114	0.00033	0.00237	0.00118	0.00118
Elimination of rise and fall	0.00002	0.00001	...	...	...	...
Alinement improvements	0.00060	0.00028	0.00011	0.00010	...	...
Total mileage-element savings	0.00518	0.00184	0.00068	0.00291	0.00118	0.00118
Time-element savings	0.01700	0.00858	0.00624	0.00500	0.00338	0.00279
Grand total of unit-traffic benefits	0.02218	0.01042	0.00692	0.00791	0.00456	0.00397

with his neighbor who maintains an automobile. . . . It is true that in many cases certain individuals will not avail themselves of all these advantages. This does not argue against their value or existence. . . . The stand-by value of these facilities rather than their actual use-value must therefore be considered when casting up the benefits of highway transport."

Lack of space precludes discussion of the methods developed for calculating the transmitted benefits. Table III, however, shows the results of these studies. Utilizing the data contained therein, the final distribution of motorized-transport benefits is readily derived. The totals for the Oregon network are given in Table IV. From these values the cost apportionments for each of the highway systems are readily derived by applying the quite obvious theory that costs should follow benefits. For example, for the R-1 system, the equitable percentage cost allocation to the road user is 79,870 ÷ 99,055, or 80.63 per cent; to the community, 18.03 per cent; and to the land, 1.34 per cent.

Table III. Impingement of Excess Benefits

Class of Traffic	Road Systems	Beneficiary
Private passenger cars	All	Road user
Commercial passenger cars	R-1, R-2, U-1, and U-2	Community
	R-3 and U-3	Land
Private-use and commercial trucks .	R-1, R-2, U-1, and U-2	Community
	R-3 and U-3	Land
Land-service trucks	All	Land
Buses	All	Community

EQUITABLE AND OPTIMUM ALLOCATION OF FUNDS

It now becomes necessary to determine the percentage of funds from each of the various sources of revenue that should be allocated to each of the various street and road systems. In seeking this allocation, the first method of approach is an extension of the criterion first stated—that taxes and imposts be levied against each of the beneficiary groups in proportion to the benefits derived. This principle has been utilized in the preceding discussion as a basis for the determination of cost distribution among the beneficiary groups, and it is apparent that it may be extended to operate as a control for the distribution of each fund among the component systems. Having once assessed and collected these taxes on the basis of benefits, and benefits alone, equity demands that they be expended where the benefits accrue, and in direct proportion to the benefits accruing. Furthermore, unless this pro rata allocation be followed, those very benefits upon which the taxation was based cannot be maintained—whereupon the consideration vanishes and the tax structure collapses.

Table IV. Final Distribution of Motor-Transport Benefits

Beneficiary Group	Total Annual Transportation Benefits, in Thousands of Dollars, for System						
	R-1	R-2	R-3	U-1	U-2	U-3	Total
Road user	79,870	3,305	1,114	7,170	2,494	1,358	95,311
Community	17,857	1,737	37	1,431	617	6	21,685
Land	1,328	149	554	66	23	419	2,539
Total	99,055	5,191	1,705	8,667	3,134	1,783	119,535

However, the case in favor of tax-fund distribution in direct proportion to benefit returns does not need to rest upon this theory alone. One of the fundamental criteria for highway taxation is that tax moneys received from each beneficiary group be distributed for expenditure in such manner as to produce maximum benefit returns to that group; and it can be demonstrated mathematically that such maximum returns will result when and only when the allocation from any given fund to each of the component systems is such as to make the various benefit-expenditure ratios equal; that is to say, when each fund is distributed among the various highway systems in direct proportion to the benefits rendered by the systems.

It follows that the equitable and optimum apportionment of any given fund among the various component systems may be derived directly from Table IV by direct proportion. For example, the road-user fund should be distributed as follows: 79,870 ÷ 95,311, or 83.799 per cent, to the R-1 system; 3,305 ÷ 95,311, or 3.467 per cent, to the R-2 system; and so on.

It should now be clear that the percentage cost allocations for each particular highway system are determined by vertical ratios in the corresponding column of Table IV, whereas the distribution of each particular fund to the various systems is determined by the horizontal ratios in the corresponding line. These ratios, in percentage form, developed from Table IV, are given in Table V.

CONCLUSIONS

Table V indicates the equitable and optimum tax allocations for Oregon. Obviously a similar table can be developed for any other state-wide network. These ratios are based solely upon benefits to motorized transport. Therefore they may or may not be adequate to meet annual needs, depending entirely upon the outstanding equities in each case. The method of determining this is briefly as follows:

Table V. Direct Annual Motor Transportation Benefits (Expressed as a Percentage of the Total)

Beneficiary Group	Percentage of Total Motor Transport Benefits on Highway System						
	R-1	R-2	R-3	U-1	U-2	U-3	Total
Road user	66.817	2.765	0.932	5.998	2.087	1.136	79.735
Community	14.939	1.453	0.031	1.197	0.516	0.005	18.141
Land	1.111	0.125	0.463	0.055	0.019	0.351	2.124
Total	82.867	4.343	1.426	7.250	2.622	1.492	100.000

1. The percentage values in Table V are first applied to the total annual cost requirements for the entire network, thus determining the equitable and optimum allocation from each fund to each system.

2. If, under this method of allocation, any system receives more than enough to meet its annual needs, the entire table must be scaled down accordingly, maintaining the same ratios throughout.

3. This last procedure will, of course, result in the establishment of certain deficits. These deficit values represent needs whose warrant lies in the second class of benefits (designated earlier in this paper as "residual" benefits). These are benefit values outside the realm of motorized transport—values that would still accrue if the only means of egress and ingress were by horse-drawn traffic or pedestrian locomotion. Clearly, then, such deficits must be funded by taxes other than motor-vehicle imposts.

The preceding outline has been of necessity somewhat sketchy and incomplete. A detailed discussion of the various phases involved is given in Bulletin No. 10, recently issued by the Oregon Highway Department. Copies of this bulletin are available for distribution to any one interested.

Small-Scale Simulation of Tidal Phenomena

A Description of Model Apparatus Used to Reproduce Tides, Waves, Littoral Drift, and Propeller Action

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Among the most complicated hydraulic model studies undertaken recently at the U. S. Waterways Experiment Station, Vicksburg, Miss., are several which are tidal in nature; that is, the proper conduct of the studies involves the simulation on a small scale of the various natural phenomena resulting from or accompanying tides. Included in these phenomena are the tides themselves; the resulting tidal currents; waves; littoral currents and the resulting along-shore movement of beach sand; and silting in tidal bays and estuaries. Another phenomenon that must sometimes be reproduced in models is the movement of sand resulting from the stirring effect of ships' propellers in shallow channels. The ingenious apparatus that have been developed to produce these various effects are described here.

The purpose of this paper is to describe the mechanical apparatus and the methods which are used at the U. S. Waterways Experiment Station to simulate tidal phenomena. The items of apparatus, and the methods herein described, represent years of development—development which has been contributed to by many hydraulic laboratories over the world. It should be understood that the apparatus and methods described herein do not insure precise simulation of the particular tidal phenomena concerned. Rather, the various elements of the model tidal phenomena are adjusted by the all-important process of "verification"—this process causing a resultant force approximately similar to the corresponding resultant force in the prototype. The principle of verification was described in the article by Paul W. Thompson, Jun. Am. Soc. C.E., in the April 1938 issue of Civil Engineering, and will not be further discussed here.

Tide-Control Apparatus

The model of the East River (New York harbor), now in operation at the Station, illustrates the type of apparatus used for reproducing tides. The model (Fig. 1) is designed and constructed to a horizontal scale of 1:480 and a vertical scale of 1:80. Inasmuch as the study is concerned only with current directions and velocities, and inasmuch as the bed and banks of the East River are relatively stable, the model is of the "fixed-bed" type; that is, it is constructed of concrete, no facilities being provided for the reproduction of the movement of materials along the bed or in suspension. Water is supplied to the model at three locations—at Whitehall (the Battery), at Clason's Point, and at Spuyten Duyvil. At each of these points the elevation of the water surface in the model is controlled continuously in such manner that the surface reproduces, to scale, an average spring tide. (The relations of the tides at the three control stations are shown in Fig. 2.)

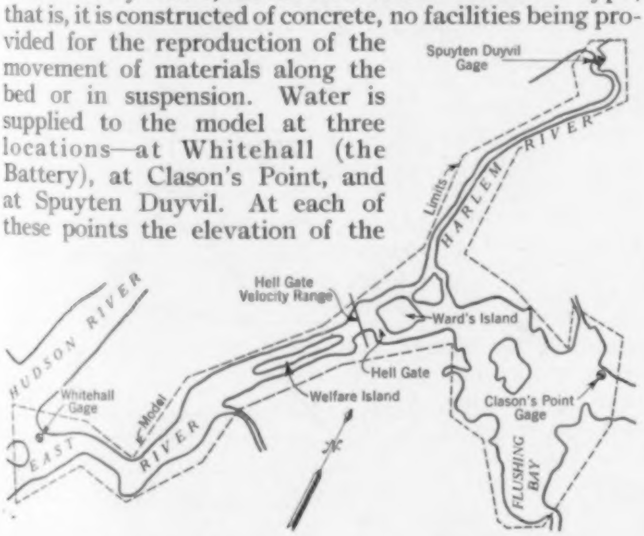


Fig. 1. Area Reproduced in East River Model

From the standpoint of model technique, the apparatus for controlling the water-surface elevation at each of these control stations is perhaps the most interesting item of equipment on the tidal model. The method used at the Station may be called the "electro-mechanical" method, to distinguish it from the electrical developed at the Massachusetts Institute of Technology and used on the Cape Cod Canal model. The electro-mechanical method is an adaptation of the method developed at the Preussischen Versuchsanstalt für Wasserbau und Schiffbau in Berlin, Germany. The method is described in the following paragraphs.

A constant supply of water is introduced into each of the three entrance pits, the quantity at each pit being in excess of the maximum amount required at any time at that point. The fundamental principle is that a varying fraction of the total amount of water supplied to each pit is diverted over the movable waste weir or gate which

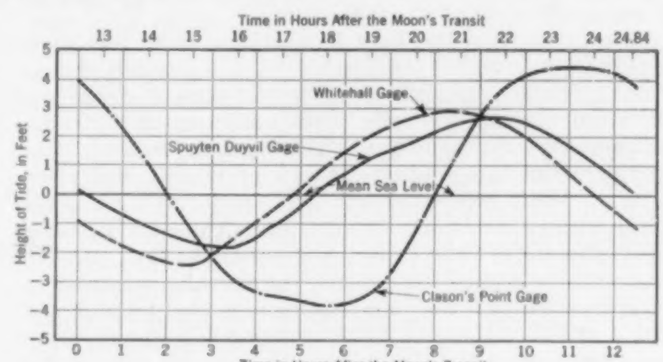


Fig. 2. Relation of Average Spring Tides at Control Stations, East River Model

forms one wall of the pit into which the water is supplied. The remaining fraction of the water flows into the model. The tide-control apparatus which controls the elevation of the waste weir—and thereby controls the water-surface elevation—is pictured in Fig. 3. (One of these devices is installed at each entrance pit.) The vertical cam is simply a polar plot of the tide which is to be reproduced. This cam is revolved by a synchronous motor at a speed corresponding to the computed time-scale of the model. Riding on the cam is a roller to which is attached, through

a vertical shaft, a split electrical contact. Meanwhile, riding on a float is another contact. Thus the split contact reflects the water surface as it should be; the single contact reflects the water surface as it actually is. When they are in agreement, the two contacts remain separated; when the water surface is not at correct elevation, contact is formed, a mercury switch is thrown, and a 220-v motor raises or lowers the movable waste weir until the water surface is at correct elevation. Thus the process is one of hunting—that is, an intermittent rise and fall of the gate in its endeavor to establish in the model the water surface demanded by the tide cam.

Because of the lag between the action of the gate and the resulting change in the water surface at the float, there is a tendency for the individual gate movements to be too long. To control this tendency, there is installed in the activating circuit an "interrupter" which, adjusted experimentally, allows the gate motor to move only about 10 per cent of the time the contacts indicate a need for a correction of the water surface.

Fig. 3. Tide-Control Apparatus and Automatic Recording Gage at Clason's Point Control Station, East River Model

Note Accuracy of Tide-Reproduction, as Shown by Curve on Recording Drum. The Clock Indicates Lunar Time, Referred to Time of Meridian Passage of Moon at Longitude of East River

It should be noted that the tides can be physically controlled only at the model entrances; at intermediate points the only control is that resulting from roughening or smoothing the model bed. Figure 4 illustrates the accuracy with which the tide was reproduced at the Whitehall gage. This figure also shows the accuracy of reproduction of the current velocities which have been measured on a range across Hell Gate. In Fig. 5 are illustrated the currents existing in the vicinity of Hell Gate at the time of strength of ebb.

A refinement of the East River tide-control apparatus has been included in the design of the Galveston Harbor model, recently completed. This refinement consists of an automatically controlled gate valve which varies the amount of water supplied to the entrance bay and thus supplements the gate apparatus previously described. The device is similar to one developed and used in the Hydraulic Laboratory of the Massachusetts Institute of Technology. The principle involved in the operation of the valve is similar to that of the movable waste weirs. A split contact rides on a cam that is the polar plot of the position of the gate valve (which has been previously calibrated in place) necessary to provide the proper quantity of water at all times during the tidal cycle, including a small constant quantity which is wasted over the gate. The cam is driven by a synchronous motor at the same speed as that of the tide cam. Another contact rides on the valve stem. The closure of an electrical circuit through these contacts energizes a motor that moves the gate valve up or down. The net result is to increase the accuracy of the tide reproduction by lessening the load on the waste weirs.

WAVE MACHINES

The matter of waves is not pertinent to the East River problem. On most of the other tidal studies conducted at the Station, however, the reproduction of waves is of importance. Two radically different types of wave machines (designated the "plunger" type and the "roller" type) are used at the Station to meet this need.

The plunger type is used in models in which it is necessary that the waves produced be of exactly the correct height, form, length, and period. Such machines have been used at the Station in the Port Washington (Lake Michigan) study, in which the problem was the reduction of wave heights in the harbor slips; in the Ballona Creek (Los Angeles, Calif.) study, in which the problem involved the movement of beach sand, principally from wave action; and in the Maracaibo outer bar (Venezuela) study, in which the problem involved the movement of sand, resulting principally from the action of waves and tidal currents.

The plunger type of wave machine (Fig. 6) consists of a triangular-shaped plunger which is made to oscillate vertically by means of a system of shafts and variable-throw cranks driven by electric motors. The magnitude of the oscillation—which governs the wave height—is controlled by the throw of the crank arms, and the wave period is controlled by the size of the pulleys on the driving motors. The wave machine is mounted on the flat bed of the wave-machine pit. In some installations, casters under the machine allow it to be swung through a horizontal angle large enough to allow waves to be produced from any desired angle with the coast line.

The roller type of wave machine is used in models in which the principal purpose of the waves is to provide turbulence, but in which the exact form of the resulting wave is not considered of importance. One example of such an installation is in the Mare Island (San Francisco Bay) model, in which it was necessary to reproduce the waves in San Pablo Bay which throw mud from the bottom into suspension. The machine consists essentially of a horizontal pipe 6 to 12 in. in diameter, eccentrically connected to a revolving shaft driven by electric motors. The amount of the eccentricity determines the size of the wave produced by the eccentric revolution of the pipe, and the speed of rotation determines the period of the wave. The roller-type wave machine has the

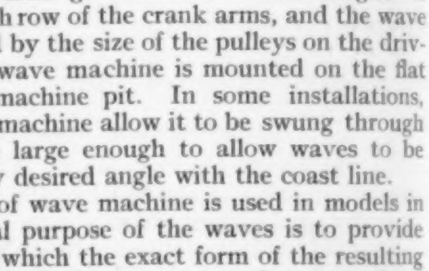


Fig. 4. Examples of Model Verification, East River Model

advantage of low cost of construction and simplicity of operation, but it has not yet been developed to the point where a wave can be produced which is entirely free from secondary waves. Hence the plunger type of machine is used in models where the form of the wave is important.

LITTORAL DRIFT APPARATUS

Weak littoral currents are induced in tidal models by virtue of the angularity of approach of the waves. Because of the limited area reproduced in the models, however, the action of the waves alone is not usually sufficient to create continuous littoral currents; rather, the waves tend to set up opposing eddies within the area representing the ocean, the resulting along-shore currents varying in direction at various locations along the beach. The expedient adopted in order to produce hydraulically the necessary littoral currents is described in the following paragraph.

Fig. 5. Currents in Vicinity of Hell Gate, East River Model, at Strength of Ebb

White Streaks Represent Paths of Confetti. Note the Large Eddy off Hallet's Point, and Sharp Changes in Direction of Currents Through Hell Gate

The entrance pit at the ocean end of the model is separated from the model proper by a solid wall, the only connections between the two areas being two pipes which lead from the pit to the two extremities of the beach. A double water-supply line is connected by tees to these two pipes. By manipulation of the four valves in the lines (two valves in each of the two connecting lines), the water supplied to the model can be caused to flow through either of these pipes to one end of the beach, thence along the shore to the other end of the beach, and thence through the other pipe back to the entrance bay, where it is wasted over the movable weir. This circulation sets up a littoral current in the desired direction along the beach. The strength of the current can be controlled by the valve openings. In any case, the velocity of the current is always established at a value less than that required, by itself, to move the beach material. The waves throw material from the beach into temporary suspension as they roll along the beach. The steady, though slow, hydraulically induced littoral current is sufficient, along with the action of the waves, to cause the material to be moved steadily along the beach.

APPARATUS DEVELOPED FOR SIMULATING THE ACTION OF BOAT PROPELLERS

It has been necessary in one model—that of the Maracaibo outer bar, Venezuela—to reproduce the disturbance of the bed material which is caused in nature by the propellers of boats passing through a narrow, shallow channel. It is only the frequent passage of oil tankers that has prevented the channel across this outer bar from becoming completely shoaled in the last few years.

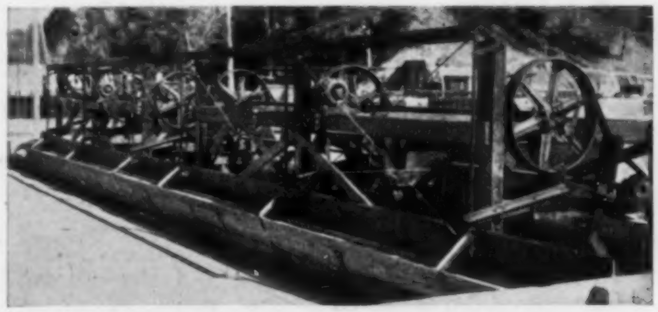


Fig. 6. A Wave Machine of the Plunger Type

Hence in the model-analysis of the problem it has been necessary to reproduce the effect of the ships' propellers.

The apparatus constructed for this purpose is pictured in Fig. 7. Twin propellers are mounted on a vertical shaft which is attached to a steel frame mounted on wheels. An electric motor drives this framework in either direction along a long, narrow platform supported on two channel beams. The ends of these channels are mounted on wheels which run on steel channel beams set in the bed of the model. A second electric motor drives the long platform in either direction along the channels. A third motor drives the propellers themselves. To simulate changes in course of the vessels navigating the channel, the propeller shaft is rotated by means of a tiller arrangement.

The three motors are operated from the control board visible at the left side of Fig. 7. By proper control the propellers can be made to follow the path of any existing channel across the bar. During the verification of the model (which reproduced a period of seven years in the prototype), the channel shifted to the westward about one mile. As the verification test progressed and the channel in the model moved to the westward (as a result of the conditions set up by the tidal currents, littoral currents, and waves), the model propellers were made to follow the path of the shifting channel.

The intent of this article is not to convey the impression, either that the apparatus and methods herein described have been perfected, or that these apparatus and methods permit the successful model-analysis of all tidal problems. The period of development is still in progress—as evidenced by the fact that each new model generally involves improvements and refinements not found on its predecessors. Meanwhile, the successful model-analysis of a tidal problem—like the successful analysis of any other problem—depends not only on the mechanical skill of the experimenter. It depends also on the intricacy of the problem, on the prototype data available (on these data depends the all-important model "verification"), and on the funds available. This article simply has endeavored to describe the means whereby approximate simulation of tidal phenomena may be attained—and the conclusion is that the engineer who is confronted with a tidal problem should investigate the possibility of help through the medium of model-analysis.

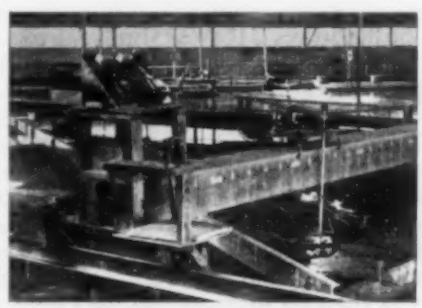


Fig. 7. Apparatus Used to Simulate Action of Ships' Propellers

Highways from the Users' Standpoint

Some Dangerous Trends That Threaten the Development of a Great Transportation Facility

By Chester H. Gray

Director, National Highway Users Conference, Washington, D.C.

AMONG the danger signs in the development of highway transportation, Mr. Gray sees first the tendency toward unplanned expansion in highway building. He urges support for planning surveys which will act as a guide to future construction. Other danger signals are the effort to destroy competition by "coordinating" all transport facilities; to levy highway taxes beyond the users' ability to pay; to divert highway funds to other uses; to revert to the toll system; and to create state "ports of entry." His paper, which was originally presented before the Highway Division at the 1938 Annual Convention of the Society, is here given in abridged form.

IT is of prime importance that all highway users should recognize the vital role played by the highway in local and national transportation, both of persons and products. The highway is not merely a playground for citizens after office hours, during holidays, and over week-ends; it is a transportation utility without which this nation cannot well exist. Unfortunately, this does not seem to be universally recognized. Certain trends are evident today that threaten the rational development of this transportation facility, and highway users must be on their guard. There are some danger signs, some red lights, which they dare not pass without notice.

A most prominent danger sign is the tendency to construct highways indiscriminately, without regard to the highway users' ability to pay for them or maintain them. We need look no farther than the history of another great and effective transportation medium—the railroad—to see what harmful results may develop from careless planning, even lack of planning, and flagrant expenditure of money. Among the causes that have placed the railroads in their present uncomfortable financial position is the fact that a considerable mileage of railways was built through regions that could not be expected to develop the necessary traffic, and in too many cases in parallel and duplicating lines. The American public is not evidencing an ability to pay freight rates to keep these unnecessary and unwise railway mileages in operation. The same thing may happen to the highways if they are built too carelessly.

Highway users should therefore give their fullest support to the highway planning surveys now being conducted cooperatively by the U. S. Bureau of Public Roads and the state highway departments. When these surveys are completed and made accessible to state and federal officials and the interested public, proper watch and compass will be available for each state and county in determining where to build, how to build, and perhaps more important, where not to build, highways. There will then be little excuse for doing what has been done too often heretofore, through no one's fault—that is, building highways with improper sight distances, unsafe curves, dangerous railroad crossings, wrong locations, and a lot of other errors that are now being corrected at a rather vast cost to the tax-paying public. Incidentally, the burden is particularly heavy on the highway user, who, in motor imposts of one kind or another, foots a very large part of the highway bill.

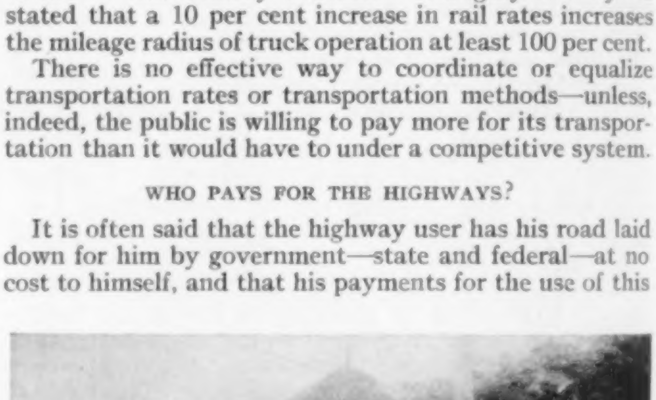
There are definite trends now to "coordinate" or "equalize" the various means of transportation. Perhaps, in discussions of these trends, too much attention is given to the transportation systems involved and too little to the fellow who pays the freight and transportation costs. Highway users insist that competition in transportation, reasonably regulated by law, should be the rule rather than coordination or equalization.

The railroads, which are indeed in direful straits, appear to be approaching the solution of their problem by advocating that all other methods of transportation be as severely regulated as they are; or, that failing, that railroad rates be raised. Both of these solutions to the railroad problem would appear to be more or less in error. The railroads would be wiser to cooperate with all other methods of transport in an effort to secure a minimum, rather than a maximum, of state and federal regulation. In regard to raising freight rates, it might be well to point out that when one method of transport raises its costs to the shipper, or beyond the shipper's ability to pay, that agency loses rather than gains business. There are numerous instances to show that when the rail rate is raised the radius of economic operation of trucks is immediately increased. Roughly it may be stated that a 10 per cent increase in rail rates increases the mileage radius of truck operation at least 100 per cent.

There is no effective way to coordinate or equalize transportation rates or transportation methods—unless, indeed, the public is willing to pay more for its transportation than it would have to under a competitive system.

WHO PAYS FOR THE HIGHWAYS?

It is often said that the highway user has his road laid down for him by government—state and federal—at no cost to himself, and that his payments for the use of this



Courtesy U. S. Bureau of Public Roads

An Old Toll House on the Cumberland Road near Frostburg, Maryland

Current Proposals for Toll Roads, Says the Author, Are a Retrogression in Transport Economics; "Highway Users Want None of It"

highway, and his contributions to its maintenance, are trivial. This is an argument that highway users must face as it is being shouted, seemingly, from every housetop. Some data on this matter should be of interest.

There are approximately 4,250,000 trucks in use at the present time, 85 per cent of them owned and operated privately by citizens hauling their own products to market or transporting supplies to their own places of business. The largest single group of private truck operators is of course the farmers. The privately owned and operated trucks pay on an estimated average $81 each in annual registration fees—a grand total of approximately $283,000,000 for the nation as a whole. These figures do not include other motor imposts and gasoline taxes that are paid alike by the private truck operator and all other highway users. In fact, this type of operator is in danger of being taxed and regulated so severely that he can only with the greatest difficulty use his own truck for his own business. Yet these private operators, being scattered so widely over the nation and working in individual units, hardly realize the restrictive and restraining regulations which are being wrapped around them. If they are forced out of operation by inordinate taxation or extreme regulation, the greatest competitor to the railroads will have been removed.

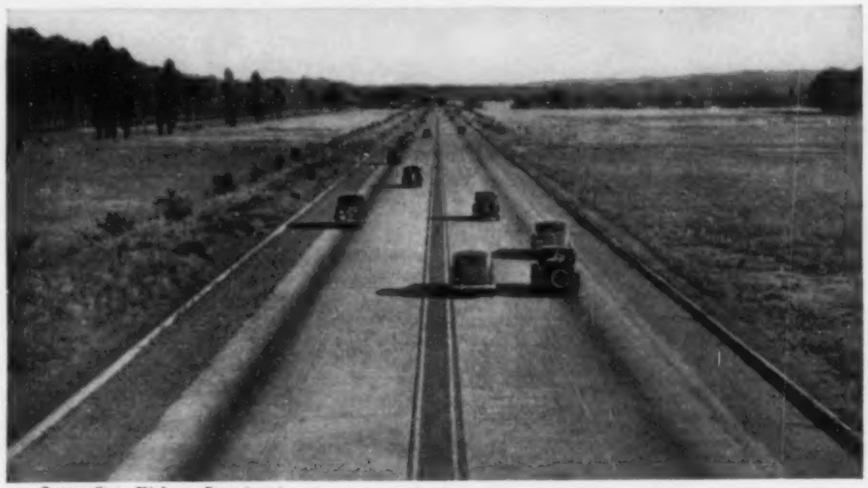
Overshadowing the tax cost paid by the private truck operator in registration fees, there is an annual grand total of $1,654,124,000 paid by the nation's highway users in various and sundry ways. In this large total is included $236,975,000 of auxiliary taxes on highway users, such as the taxes paid by motor bus operators, private and public garages, accessory dealers, and filling stations. Total state taxes paid by highway users annually amount to $1,066,340,000 of which $686,631,000 are motor fuel taxes. Total registration fees for the nation are $359,783,000. Federal taxes on gasoline, autos, tires, and so forth are $292,408,000 annually. These statistics suggest that the highway user is paying rather appreciable sums for his use of the highways for business or pleasure.

THE DANGERS OF TAX DIVERSION

Closely connected with the question of highway imposts is the matter of dedicating the revenues derived from these imposts exclusively to highway building, maintenance, and the retirement of highway obligations. In recent years acute needs have developed in various states for more funds for a multitude of state functions which are of themselves no doubt worthy. Temporarily there have been visible, in certain states, sizable highway funds not immediately allocated to projects of a highway character; so state legislatures and governors have reached out to these funds and have appropriated them to the general purposes of government. In other words, the highway users—a special group—have been compelled to support general functions and activities of government simply because they happen to be highway users.

This is a very dangerous precedent. All groups of citizens interested in the dedication of special revenues for special purposes should realize that the diversion of highway funds is an open threat to all such funds.

The annual total of national diversion, from data of the U. S. Bureau of Public Roads, when last tabulated (1936), was $169,344,000. This sum is sufficient to have constructed a total of 33,800 miles a year of secondary roads (at $5,000 a mile), or 6,760 miles of primary roads (at $25,000).



Oregon State Highway Department

A Trunk-Line Highway in Oregon

TOLL ROADS AND SUPER-HIGHWAYS

We hear a great deal now about super-highways and toll roads. And truly, highways have come to be such an important commercial transportation facility that our plans for building them must be enlarged. But therein lies the danger. Some want to build highways and revert to the toll system to liquidate their costs. That plan obviously is a retrogression in transport economics. Highway users want none of it. They are willing to pay for highways by proper imposts and taxes which all highway users must pay, and which, when paid, will be applied to the provision of free, not toll, highways.

Safety on the highways calls for specially constructed roads and crossings where traffic surveys have demonstrated that the more expensive types of roads are needed. It is ridiculous, however, to talk about building long transcontinental super-highways, for it can be shown that traffic would be inadequate to justify them. Again we must place reliance on highway planning, and build our more expensive roads only where accurate surveys demonstrate the need for the more elaborate types. In time this development may give us some connecting highways between cities rather far apart—but such routes should be built only as the need arises, not through politics or propaganda with the idea that the need may ultimately develop.

Finally, attention should be called to the matter of state ports of entry. If there is any one thing that is out of keeping with the constitutional development of interstate commerce, it is the port-of-entry legislation that has been enacted in several states, most of them in the West. Fortunately the states that have been most active in this type of legislation are slowly discovering that national ill-will is created against them by the setting up of border barriers almost equivalent to the provincial boundaries in foreign nations. Not alone from the standpoint of the highway user, but from that of the nation as a whole, this port-of-entry development must be viewed with alarm.

Role of Highways in Recent California Floods

Road Network Takes On Added Value in Time of Emergency

By F. W. Panhorst

Member American Society of Civil Engineers

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In times of calamity, says Mr. Panhorst, a network of highways offers advantages beyond those possessed by any other carrier. Taking the California floods of 1937–1938 as a case in point, he presents a well-selected list of incidents that demonstrate this thesis. A brief description of the floods provides the background for an appreciation of the examples. This article is an abridgment of a paper presented before the Highway Division at the 1938 Annual Convention in Salt Lake City, Utah.

This paper does not discuss the economic or technical factors that may correlate highway construction with periodic floods. But it does attempt to show, by a few definite examples from recent experience in California, the use of highways in alleviating the distress and loss occasioned by floods—a value not commonly included in highway appraisal.

To provide the proper background for these examples, let us first consider briefly the California floods of 1937–1938, and the nature of California floods in general.

The streams of California are grouped in six major divisions or basins—the Sacramento basin, San Joaquin basin, San Francisco basin, North Pacific basin, South Pacific basin, and the Great Basin (Fig. 1). Flood damages are of most significance in the Sacramento and San Joaquin basins, because of their extensive agricultural area, and in the South Pacific basin, which includes the metropolitan area of Los Angeles and the valuable citrus lands of southern California. The San Francisco Bay basin, while embracing a highly developed area, does not include streams sufficiently large to cause extensive flood damage, and in the North Pacific basin the streams, though large, are mainly confined within deep gorges. The Great Basin includes the more arid region along the eastern boundary of the state and does not include many streams of great perennial yield. It is, however, subject to cloudbursts that produce flashy runoffs damaging to highways and railroads.

Any description of California floods should differentiate between northern California, as exemplified by the Sacramento and San Joaquin River systems (that is, the "Central Valley"), and the quite dissimilar conditions of the Los Angeles, San Gabriel, and Santa Ana rivers, in the South Pacific basin. The 60,000-sq mile watershed of the great Central Valley forms one of the most complicated river systems of the United States, as it drains thousands of square miles of high mountains where different combinations of elevation, topography, and weather over a wide range of latitude produce innumerable streams of variable temperaments. Except for transportation and communication lines, flood damage is limited largely to the flat areas of the two trunk streams and the short level reaches of the main tributaries from the Sierra Nevada. The maximum floods result from a long period of appreciable precipitation followed by an intense general storm with high temperatures and melting snow on the upper levels. Flood hydrographs in the steep mountain areas parallel the rainfall graphs and have sharp peaks reflecting only the more intense portions of the storms, while on the lower reaches of the Sacramento and San Joaquin rivers, dangerous stages fluctuating less than 5 ft may last almost two weeks.

In southern California the situation is entirely different. It requires only the aggravation of a short intense rainfall on the steep and relatively barren slopes to produce runoff rates commonly in excess of 200 cu ft per sec per sq mile, with estimates of 700 cu ft per sec per sq mile on minor areas. The major streams of this area, the San Gabriel and Santa Ana rivers, have flood-yielding sheds of but 220 and 700 sq miles, respectively. Yet within a few hours a normally dry river bed can attain discharges of 40,000 cu ft per sec, at velocities of 10 to 20 ft per sec. At such times tremendous amounts of debris are transported; river channels may change completely during a single flood; and extensive deposit and scour in the space of a few hours may transform valuable citrus lands into a boulder-strewn waste. The seriousness of such floods is apparent when it is remembered that almost half of the state's population is concentrated in the alluvial fans and plains practically at the very edge of the mountains. Unregulated flood crests in southern California generally pass within a single day; but the resulting moderately high stages prolong distress by retarding repair work, and by continuing to a lesser degree the scour and deposit started by the higher flows.

The flood of December 1937, in the Central Valley, and the one of March 1938 in southern California were more severe and destructive than any of the preceding

When Last Winter's Floods Tied Up the Railroads in California, the Highways Readily Assumed the Burden of Additional Freight and Passenger Traffic

If a Main Route Was Blocked, Some Interconnecting Road Was Almost Always Available

20 years. The total flood damage over the state during the winter and spring is estimated to be more than $60,000,000; damage to state highways is estimated at approximately $8,000,000, and damage to public service companies, at approximately $16,000,000.

THE FLOODS OF 1937–1938

On Thursday night, December 9, 1937, general rains were falling over the entire state, and in the northern part the precipitation on both December 10 and 11 was exceptionally intense. The most remarkable feature of the storm was the intense rainfall up to elevations above 7,000 ft. (Ordinarily, at that season, precipitation changes from rain to snow between the 3,000 and 5,000-ft level.) At Buck's Lake, at an elevation of about 5,000 ft on the Feather River shed, 8.04 in. of rain fell December 10 and 9.04 in. the following day.

By the evening of December 10, the mountain streams in the northern half of the state were approaching flood stage and within the next 24 hours passed their crests onto the valley floor. The flood crest passed into San Francisco Bay on December 15. At many points stages exceeded all-time records as discharges approached the 1907 figures. In the Sacramento Valley, the levee system broke at a number of places, causing great damage to farms and towns and forming an inundated area 30 miles wide in the vicinity of Colusa. In the San Joaquin Valley, the damage was largely limited to the foothill and mountain districts and to the lower Kaweah and Kings rivers, where large farm areas were flooded. The discharge of the Kinds River reached 80,000 cu ft per sec, one and one-half times the previous maximum recorded since 1896. A discharge of 30,000 cu ft per sec is normally considered a severe flood on this stream.

The inundated areas obviously obstructed transportation lines in the lowlands; but the greatest damage to such facilities occurred along the foothills and in the mountains. On some of these mountain streams, with drainage areas of 30 sq miles and less, flood crests of 6,000 to 15,000 cu ft per sec were attained within less than an hour. Culverts that had been ample for almost half a century were practically ignored by flows carrying logs 80 ft long and 4 ft in diameter. Many highway roadbeds were undercut and badly damaged. The preliminary estimate of damage resulting from this flood is $14,600,000, of which $4,500,000 is for highways, roads, and streets.

In southern California, the floods came in March. From February 26 through February 28, approximately 5 in. of rain fell throughout the area and thoroughly saturated the ground. A more severe storm swept the entire area on March 2 and 3. This storm was especially intense in the mountain areas of the Los Angeles, San Gabriel, and Santa Ana River basins. The Los Angeles rainfall of 10.69 in. exceeded all records for a comparable period during the past 61 years. At Lake Arrowhead, in the Santa Ana watershed, storm totals reached a maximum of 30 in. Stream discharges approached or exceeded the "once-in-fifty-year" theoretical maximums.

The debris-laden waters rushed down the valleys, undermining bridges by the score, and spread out over flat lands to sweep away homes, wash out highway and railroad roadbeds, and deposit silt to 6-ft depths in highly improved residential and business districts. Power and gas lines were severed, communication lines destroyed, and railroads and highways put out of service. Some communities were completely isolated for several days.

Bridge failures were largely due to scour under the piers. So great was this cutting that several large plate-girder spans which dropped were completely buried and lost. No particular type of structure displayed outstanding superiority. Short-span trestles, of course, were especially vulnerable because of their tendency to catch drift and wreckage.

Serious damage to transportation routes was not confined to the Pacific slope. The Mojave River, a desert stream that drains the bare northern slope of the San Bernardino Mountains, ran wild and damaged long stretches of two transcontinental railroads besides causing loss to highways and towns. Southeast from San Bernardino, on the desert slope beyond San Gorgonio Pass, a number of streams played havoc with the Los Angeles–New Orleans line of the Southern Pacific Railroad, damaged highways, and completely isolated the desert resort of Palm Springs.

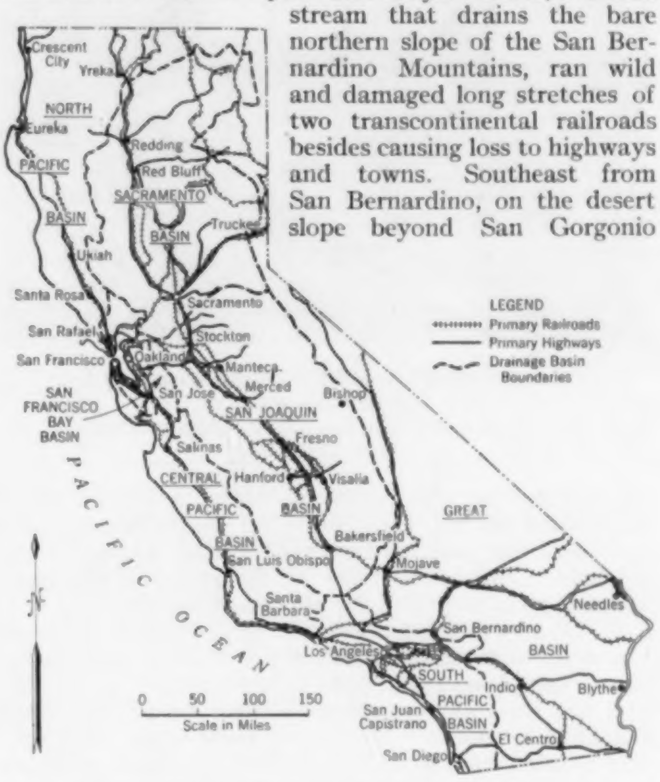

FIG. 1. CALIFORNIA, SHOWING THE SIX MAJOR DRAINAGE BASINS AND THE PRINCIPAL RAILROADS AND HIGHWAYS

HIGHWAYS PROVIDE MANY INTERCONNECTING ROUTES

The recent floods demonstrated, with a clarity almost subject to statistical analysis, the extra service and utility that a highway network can, and does, give the public during times of widespread disaster. This supplementary service does not imply that highways involve superior engineering practices and less vulnerable construction than other transportation lines. It only exemplifies the availability of interconnecting routes that may be used to detour obstructions to one or more parallel roads. It also illustrates the ease and quickness with which temporary highway construction can be effected.

California embraces a pattern of 99,600 miles of roads not including those within incorporated municipalities; and 9,092 miles of steam and electric railroads (equivalent single-track mileage). In most areas the shortest and most direct routes, and often the only means of egress from low-lying lands, are highways. (In Fig. 1 only the principal routes are shown.) During the past season hundreds of residents of the lowlands were warned of the impending disaster by radio and telephone and were able to flee to safer locations with a part of their belongings.

During the December flood, in northern California, highways were used to transport materials and equipment by motor truck to strengthen levees. The three counties on the northern coast of the state are served by

U. S. Highway No. 101 and the Northwestern Pacific Railroad, both extending from the San Francisco Bay area. The railroad was closed by slides and slip outs from the middle of December to April, and the highway

MANY HIGHWAY ROADBEDS WERE UNDERCUT AND BADLY DAMAGED
A Scene on Route 4, in Los Angeles County, After the March 1938 Flood

readily assumed the additional burden as evidenced by light-truck traffic, which exceeded by 50 per cent the peak seasonal count for such vehicles during the previous summer. The heavy truck traffic in April was three times as great as that of the previous July.

In thickly populated areas such as southern California, acute distress immediately occurs when transportation of people and foodstuffs is interrupted, when power and gas lines are broken, and when people are made homeless by floods. Before the high waters of March had receded completely, the highway crews were closing gaps in roadbeds, constructing temporary stream crossings, and routing traffic over detours, so that the motorized equipment of public utility companies might reach their damaged lines and so that stranded railroad passengers could be transported to their destinations by large motor buses.

In southern California the perishable fruit and produce industry is a vital source of wealth, and even brief interruptions in its movement are attended by serious loss. The partial loss of the Santa Clara River bridge at Saticoy isolated the rich citrus lands of that district from the packing plants on the opposite side of the river. Before the flood waters had receded completely a temporary trestle had reestablished the crossing, and within a week's time the normal truck movement of the fruit was under way. This avoided a loss of thousands of dollars to the growers.

MAIL AND PASSENGERS HANDLED BY HIGHWAYS

The relation of highways to other means of transportation in conveying persons or goods must not be disregarded. The highways form a network of connecting links to rail, water, and air transportation. Although more freight tonnage is carried by rail, highway transportation at the present time involves more rolling stock, carries more passengers, has more vehicle units, and represents a capital investment greater than any other means of transportation. While in some respects the highways and railroads are competitive, each is essential to a thoroughly coordinated network of national transportation facilities. The necessity of such coordination and interrelation was demonstrated thoroughly during the recent floods, which crippled both highways and railroads.

From Los Angeles, in every direction, the highways were called upon to take over the interrupted mail and passenger service of the railroads. On the coast routes north of Los Angeles, highway crews were able to limit vehicular-traffic interruption to about ten hours. Railroad passengers and the mails were transported by buses to Santa Barbara during the two days the railroad was out of service. The Southern Pacific Railroad between Los Angeles and the San Joaquin Valley was closed for nearly two weeks. However, the railroad company was able to transport passengers and freight by buses and trucks, except for the twelve hours immediately following the flood, when the state highway over the Tehachapi Mountains was closed as a precautionary measure.

During the period in which the railroads were inoperative, which varied from six days to a month, the heavy suburban traffic from Los Angeles to the communities to the east was transported entirely over the highway network. This service was never completely severed.

The electric railroad lines from Los Angeles south into Orange Country were out of service for three weeks. The highways were closed for only twelve hours. After this period passengers were transported by buses operating between Los Angeles and Santa Ana.

Severe damage occurred to both the Santa Fe Railway and the highway routes to San Diego, but direct highway traffic was restored in two days. The railroad was opened four days later.

An almost dramatic atmosphere accompanied the great efforts of the transcontinental railroads to arrange buses and trucks to rescue stranded passengers and mail in the mountain and desert regions of San Bernardino and Riverside counties. So numerous were the points of damage that the railroads rushed mobile equipment over the highways to attack the breaks simultaneously at many points.

The Atchison, Topeka and Santa Fe main line between the desert town of Barstow and Los Angeles was closed for seven days. On March 10 one track was opened to limited train service. As soon as the railroad could organize a bus system to transfer passengers and mail, a highway route to Los Angeles was available. The principal highway route, U. S. Highway 66 through Cajon Pass, was by-passed by heavy trucks and buses until March 6 but the road accommodated light traffic by March 4.

The Union Pacific Railroad lost extensive trackage and many bridges in the desert area, but on March 4 was able to get its bus service organized. The highway bridge at Baker was weakened, and for a time the Union Pacific Railroad operated a shuttle bus and mail service from Baker to the bridge, over which passengers walked and the mail was carried. This line was out of service for a period of three weeks, during which time passengers and mail were carried to Los Angeles over the highways.

After being closed for one day, the highway between Los Angeles and Indio was able to accommodate buses and trucks pressed into service by the Southern Pacific Railroad, until their main line, southern route, was opened one week later.

The foregoing examples should suffice to convince the most skeptical that a network of highways provides a transportation system which during times of flood or other great calamity offers advantages beyond those possessed by any other carrier. That such an extra public service has not heretofore been considered in arranging highway finances is quite generally known. It should also be pointed out that these advantages do not necessarily obtain only in times of flood; they should also be considered in plans for a modern national defense.

ENGINEERS' NOTEBOOK

This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems. Reprints of the complete department, 8½ by 11 in., suitable for binding in loose-leaf style, are available each month at 15 cents a copy.

Economical Buttress Spacing for Reinforced Concrete Dams

By Franklin C. Rogers, Jun. Am. Soc. C.E.

Designing Engineer, Ambursen Dam Company, New York, N.Y.

The preliminary steps in the design of a buttress dam of either the Ambursen flat-slab type or the multiple-arch type require the arbitrary selection of many principal structural dimensions. To test the economy of the designer's judgment, it is necessary to figure a series of comparative estimates for several variations of each particular dimension. As a variation in buttress spacing results in a complete redesign of the structure in all parts, it can easily be seen that a thorough analysis for the most economical buttress spacing would prove a cumbersome and lengthy task.

Any change in the buttress spacing produces a fluctuation of the quantities required for the structure. For wider spacings the concrete quantity and the necessary reinforcing steel for the water-bearing member are materially increased, while the large form area on the buttress is distributed over a greater length of dam. Smaller spacings have the advantage of reducing the amount of concrete and reinforcement in the water-bearing member but increasing the form area per unit length of dam and, consequently, the total form cost. To locate the intermediate spacing that will give the most economical balance of concrete, reinforcing steel, and form quantities, satisfying also the stress requirements of the structure, is the ultimate aim of the designer.

If cost be plotted against buttress spacing, the resulting curve will show a definite low area indicating the range of spacings in which the greatest economy can be realized. Figure 1 shows the type of cost–spacing curve

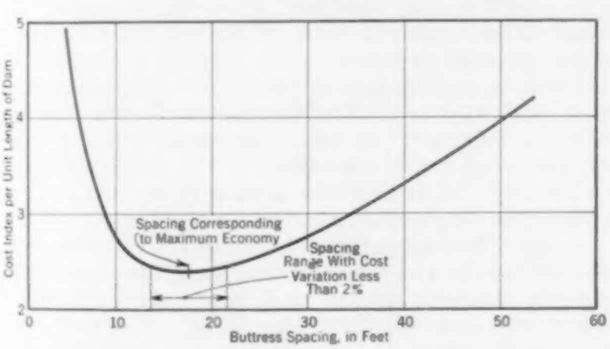

Fig. 1. Typical Relation Between Buttress Spacing and Cost of Dam

derived for an Ambursen flat-slab dam 20 ft high. The most economical spacing for this type of dam is 17.5 ft. However, the spacing can be varied 20 per cent in either direction with a cost increase of not over 2 per cent from the minimum. Since the purpose of the analysis is to determine the most economical spacing, elimination of the cumbersome mechanics of estimating is highly desirable. Expressing the relation between cost and buttress spacing as an equation permits immediate solution for the desired spacing by differentiating and solving for the minimum point on the curve.

The following algebraic analysis is for the multiple-arch type of dam. The costs of excavation and all items other than concrete, steel, and forms have been neglected on the assumption that they will not materially influence the accuracy of the final result. The following notation will be used:

Q_c = quantity of concrete, in cubic feet
Q_f = quantity of form surface, in square feet
K_c = cost of concrete and included steel, per cubic foot of concrete
K_f = cost of forms, per square foot
r = mean radius of arch, in feet
t = mean thickness of arch, in feet
z = arch design constant = t/r
ϕ = one-half of central arch angle, in degrees
L = buttress spacing, in feet
a = horizontal dimension between mean arch radii at upstream face of buttress
H = height of dam, in feet (pond level to foundation)
α = angle between upstream face of buttress and vertical
β = angle between downstream face of buttress and vertical
m = thickness of buttress at pond level for a hypothetical buttress spacing of one foot
n = increase in mean buttress thickness per foot of height for a hypothetical spacing of one foot. The mean buttress thickness for height, H, and buttress spacing, L, is $L(m+nH)$

$$A = \frac{\pi\phi}{90 \sin\phi \cos\alpha}$$

$$B = \tan\alpha + \tan\beta$$

For the same general type of dam, the weight of steel per unit volume of concrete is reasonably constant through wide fluctuations of buttress spacing. Therefore it is sufficiently accurate to include the unit cost of steel with the unit cost of concrete (K_c).

The arch design ratio, t/r, designated as z, is evaluated by the method outlined in the paper, "Laminated Arch Dams with Forked Abutments," by the late Fred A. Noetzli, M. Am. Soc. C.E. This paper (Transactions, Vol. 95, 1931) gives a series of curves which aid materially in selecting values of t/r for a wide range of central angles and allowable concrete stresses.

Referring to Fig. 2, the concrete and form quantities for the arch barrel, per unit length of dam, are respectively, $\frac{\pi r^2 \phi H}{90 L \cos\alpha}$ and $\frac{2\pi r \phi H}{90 L \cos\alpha}$. Or, substituting $\frac{L-a}{2\sin\phi}$ for r,

$$\text{Concrete volume} = \frac{AzH\,(L-a)^2}{4\,L\,\sin\phi} \quad \ldots\ldots [1]$$

$$\text{Form surface} = \frac{AH\,(L-a)}{L} \quad \ldots\ldots [2]$$

The buttress concrete and form quantities per unit length of dam are

$$\text{Concrete volume} = \frac{H^2B\,(m+nH)}{2} \quad \ldots\ldots [3]$$

$$\text{Form surface} = \frac{H^2B}{L} \quad \ldots\ldots [4]$$

Then the cost of concrete, steel, and forms for a unit length of dam of height H is

$$\text{Cost} = K_c\,[(1)+(3)] + K_f\,[(2)+(4)] \ldots\ldots [5]$$

Equation 5 gives a curve similar to that shown in Fig. 1. To locate the low point on the curve and, hence, the spacing for minimum cost, Eq. 5 is differentiated with respect to L, and equated to zero. There results:

$$L^2 = a^2 + \frac{4K_f \sin\phi\,(HB - aA)}{K_c\,Az} \quad \ldots\ldots [6]$$

The value of L from Eq. 6 will give the greatest economy for a single value of H, which is, in effect, for a dam of uniform foundation depth. However, it is more often the case that the profile will vary and the height of dam will range from a minimum at the abutments to a maximum at the stream bed. The problem is then to determine the value of L resulting in the maximum economy for the entire structure.

The cost of a unit length of dam as derived in Eq. 5 is $K_c Q_c + K_f Q_f$. To include the effect of varying heights, the cost is taken as a summation of several sections located at equidistant points across the profile:

$$\text{Cost} = K_c\,\Sigma\,Q_c + K_f\,\Sigma\,Q_f \ldots\ldots [7]$$

The solution and resulting value of the buttress spacing, L, will give the most economical buttress spacing for the combination of heights selected:

$$L^2 = a^2 + \frac{4\,K_f \sin\phi\,[B\Sigma(H^2) - aA\Sigma\,(H)]}{K_c A\;\Sigma\,(zH)} \quad \ldots\ldots [8]$$

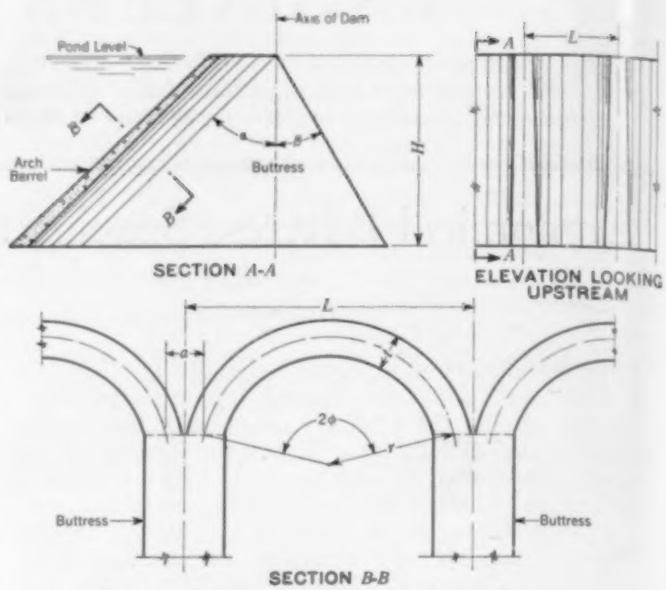

FIG. 2. SECTIONS OF MULTIPLE-ARCH DAM

The Equiangular Strain-Rosette

By RAYMOND D. MINDLIN, JUN. AM. SOC. C.E.

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THERE is developing, today, an increasing interest in experimental studies of complex stress distributions in structural elements. Engineers recognize the need for an intimate knowledge of the detailed state of stress in the material at critical regions throughout the structure. One approach to this knowledge is by means of surface strain measurements of the type known as strain-rosette.

The state of stress at a point on the surface of a stressed material is completely determined only if the magnitudes of the two principal stresses and the orientation of the axes of principal stress are known. The specification of stress in such a two-dimensional system accordingly depends upon three quantities. In any experimental determination of two-dimensional stress, therefore, three independent quantities must be determined in some manner. That is, since it is not possible to measure stress directly, at least three quantities upon which stress depends must be measured.

In the strain-rosette method, the required quantities are obtained by measuring the relative displacements of three or more pairs of points in the neighborhood of a point, P, on the surface of the stressed specimen. The strain in the neighborhood of P is assumed to be homogeneous (that is, uniform) so that three or more unit elongations can be calculated directly from the displacements by dividing the relative displacements by the corresponding gage lengths. Strictly speaking, these strain data, combined with a stress-strain relation, describe the state of stress at P. But the description is in such a form as to be almost useless for purposes of analysis. The stress analyst wishes to know either the components of stress (or strain) acting on a certain plane, or the magnitudes and directions of the principal stresses (or strains). It is therefore necessary to have available a means for interpreting the rosette readings.

In the following paragraphs there are given the theoretical bases on which rosette interpretations are founded, and the theory is applied to a very convenient form of rosette in which the three gage lines make equal angles with each other. The equiangular arrangement is chosen as an example because it leads to the most symmetrical and simple formulas possible with the necessary minimum of three gage lines. The same procedure may be followed to obtain formulas for three gage lines inclined at any other angles with each other.

BASIC FORMULA

There is a fundamental relation in the analysis of strain which connects the unit elongation in any direction with the components of strain referred to a set of coordinate axes (see Case, *Strength of Materials*, 1925, page 79):

$$\epsilon_N = \epsilon_x \cos^2\theta + \epsilon_y \sin^2\theta + \epsilon_{xy} \sin\theta\cos\theta \ldots\ldots [1]$$

Here ϵ_x is the unit elongation in the x direction; ϵ_y is the unit elongation in the y direction, perpendicular to x; and ϵ_{xy} is the shearing strain, that is, the change in angle between the x and y directions during deformation. ϵ_N is the unit elongation in a direction N making an angle θ with the x direction. θ is measured as positive in the counterclockwise direction from the x axis.

In the derivation of Eq. 1, the assumption is made that $\epsilon_x, \epsilon_y, \epsilon_{xy}$ are small relative to unity.

Equation 1 shows that, in order to calculate the magnitude of the strain ϵ_N in any chosen direction specified by θ, three quantities ($\epsilon_x, \epsilon_y, \epsilon_{xy}$) must be known. Conversely, in order to calculate the components of strain for any set of axes, three other independent quantities must be known. For example, there might be known the strain ϵ_N corresponding to three known values of θ. From these the three components $\epsilon_x, \epsilon_y, \epsilon_{xy}$ may be calculated. This is the basis of the strain-rosette procedure.

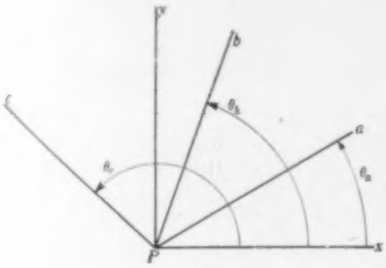

FIG. 1

The changes in length of three line segments Oa, Ob, Oc, oriented at three different angles $\theta_a, \theta_b, \theta_c$ with respect to an arbitrarily chosen x direction, are measured in the neighborhood of a point P on the surface of a stressed plate (Fig. 1). The three strains $\epsilon_a, \epsilon_b, \epsilon_c$ are the ratios of the measured changes in length to the original lengths. Three equations of the type of Eq. 1 may then be written:

$$\left.\begin{aligned} \epsilon_a &= \epsilon_x \cos^2\theta_a + \epsilon_y \sin^2\theta_a + \theta_{xy}\sin\theta_a\cos\theta_a \\ \epsilon_b &= \epsilon_x \cos^2\theta_b + \epsilon_y \sin^2\theta_b + \epsilon_{xy}\sin\theta_b\cos\theta_b \\ \epsilon_c &= \epsilon_x \cos^2\theta_c + \epsilon_y \sin^2\theta_c + \epsilon_{xy}\sin\theta_c\cos\theta_c \end{aligned}\right\} \cdots [2]$$

It is a simple process to solve for ϵ_x, ϵ_y, and ϵ_{xy}, in terms of $\epsilon_a, \epsilon_b, \epsilon_c$ for any given values of $\theta_a, \theta_b, \theta_c$.

EQUIANGULAR STRAIN-ROSETTE

The expressions for ϵ_x, ϵ_y, and ϵ_{xy} in terms of ϵ_a, ϵ_b, and ϵ_c take very simple forms when the three gage lines make equal angles with each other and when the x axis is chosen to coincide with one of the gage lines. Figure 2 illustrates such an arrangement. The gage lines a, b, and c, when arranged as in Fig. 2, form what is known as an equiangular strain-rosette. All four of the variations shown in Fig. 2 will lead to the same formulas and, on the basis of the assumption of homogeneous strain, will give equally good results.

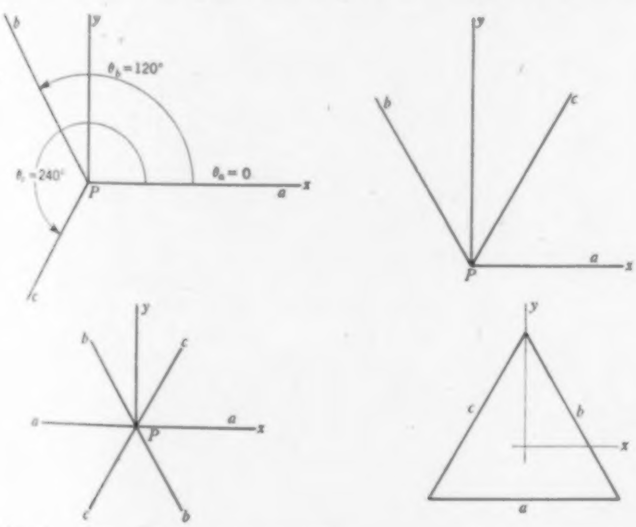

FIG. 2. FOUR FORMS OF THE EQUIANGULAR STRAIN-ROSETTE

Substituting the values $\theta_a = 0$, $\theta_b = 120°$, $\theta_c = 240°$ in Eqs. 2, there results

$$\left.\begin{aligned} \epsilon_x &= \epsilon_a \\ \epsilon_y &= {}^1/_3\,(2\epsilon_b + 2\epsilon_c - \epsilon_a) \\ \epsilon_{xy} &= \frac{2}{\sqrt{3}}\,(\epsilon_c - \epsilon_b) \end{aligned}\right\} \cdots\cdots\cdots [3]$$

The expressions for the principal strains, ϵ_1, ϵ_2, in terms of the components of strain $\epsilon_x, \epsilon_y, \epsilon_{xy}$ are:

$$\epsilon_1 = {}^1/_2\,(\epsilon_x + \epsilon_y) + {}^1/_2\,\sqrt{(\epsilon_x - \epsilon_y)^2 + \epsilon_{xy}^{\,2}}$$

$$\epsilon_2 = {}^1/_2\,(\epsilon_x + \epsilon_y) - {}^1/_2\,\sqrt{(\epsilon_x - \epsilon_y)^2 + \epsilon_{xy}^{\,2}}$$

and the angle, ϕ, which the direction of the algebraically larger principal strain (ϵ_1) makes with the x axis is

$$\tan 2\phi = \frac{\epsilon_{xy}}{\epsilon_x - \epsilon_y}$$

(see Case, op cit, page 79).

To express these three quantities directly in terms of the equiangular strain readings, it is only necessary to substitute for ϵ_x, ϵ_y, and ϵ_{xy} their values given by Eqs. 3. There results

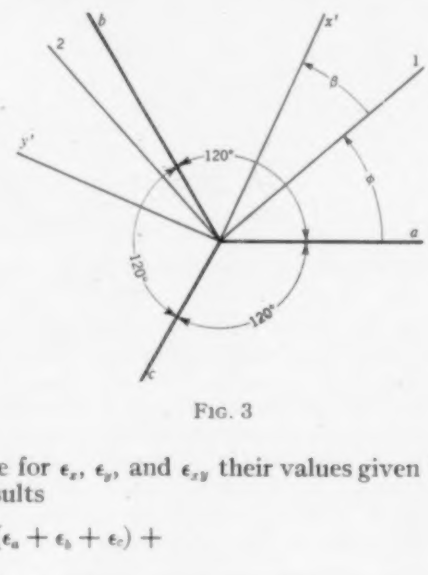

FIG. 3

$$\left.\begin{aligned} \epsilon_1 &= {}^1/_3\,(\epsilon_a + \epsilon_b + \epsilon_c) + \\ &\quad \frac{\sqrt{2}}{3}\sqrt{(\epsilon_a - \epsilon_b)^2 + (\epsilon_b - \epsilon_c)^2 + (\epsilon_c - \epsilon_a)^2} = A + B \\ \epsilon_2 &= {}^1/_3(\epsilon_a + \epsilon_b + \epsilon_c) - \\ &\quad \frac{\sqrt{2}}{3}\sqrt{(\epsilon_a - \epsilon_b)^2 + (\epsilon_b - \epsilon_c)^2 + (\epsilon_c - \epsilon_a)^2} = A - B \\ \tan 2\phi &= \frac{\sqrt{3}\ (\epsilon_c - \epsilon_b)}{2\epsilon_a - \epsilon_b - \epsilon_c} \end{aligned}\right\} [4]$$

The angle ϕ is measured as positive in the counterclockwise direction from the x-axis to the direction of ϵ_1. If $(\epsilon_c - \epsilon_b) > 0$, $0 < \phi < \frac{\pi}{2}$. If $(\epsilon_c - \epsilon_b) < 0$, $\frac{\pi}{2} < \phi < \pi$.

Equations 3 give, in terms of ϵ_a, ϵ_b, and ϵ_c, the components of strain referred to a set of coordinates for which one axis coincides with a gage line. It may be required to calculate the components of strain along some other set of rectangular axes, say x' and y'. It is convenient to designate the orientation of the new set of axes by reference to a principal stress direction.

Let the x' axis be located by an angle β measured positively in the counterclockwise sense from the axis of the algebraically larger principal strain (Fig. 3). Then

$$\left.\begin{aligned} \epsilon_{x'} &= A + B \cos 2\beta \\ \epsilon_{y'} &= A - B \cos 2\beta \\ \epsilon_{x'y'} &= -2B \sin 2\beta \end{aligned}\right\} \cdots\cdots\cdots\cdots [5]$$

In order to calculate stresses from the strains, assumptions must be made as to the relations between stress and deformation in the material under test. It is customary to assume that the material follows Hooke's Law and is isotropic. These assumptions lead to the ordinary formulas for the stress-strain relations in terms of Young's modulus, E, and Poisson's ratio, ν. For the condition of two-dimensional stress which exists on a free surface, these are

$$\left.\begin{aligned} \sigma_x &= \frac{E}{1-\nu^2}\;(\epsilon_x - \nu\epsilon_y) \\ \sigma_y &= \frac{E}{1-\nu^2}\;(\epsilon_y - \nu\epsilon_x) \end{aligned}\right\} \cdots\cdots\cdots\cdots [6]$$

(Case, op cit page 418).

Formulas for the principal stresses in terms of the strains ϵ_a, ϵ_b, ϵ_c are obtained by substituting the first two of Eqs. 4, in Eqs. 6, replacing x and y by 1 and 2 in the latter. The result is

$$\left.\begin{aligned} \sigma_1 &= E\left\{\frac{A}{1-\nu} + \frac{B}{1+\nu}\right\} \\ \sigma_2 &= E\left\{\frac{A}{1-\nu} - \frac{B}{1+\nu}\right\} \end{aligned}\right\} \cdots\cdots [7]$$

The direction of the maximum principal stress is again given by the last of Eqs. 4.

The formulas for the components of stress referred to any set of axes x', y' are obtained by combining Eqs. 6 and Eqs. 5, with the result

$$\left.\begin{aligned} \sigma_{x'} &= E\left\{\frac{A}{1-\nu} + \frac{B}{1+\nu}\cos 2\beta\right\} \\ \sigma_{y'} &= E\left\{\frac{A}{1-\nu} - \frac{B}{1+\nu}\cos 2\beta\right\} \\ \sigma_{x'y'} &= -\frac{E}{1+\nu} B \sin 2\beta \end{aligned}\right\} \cdots [8]$$

For those familiar with the Mohr circle diagram, Fig. 4 is given to show how simply Mohr's circle may be constructed directly from the strain-rosette data.

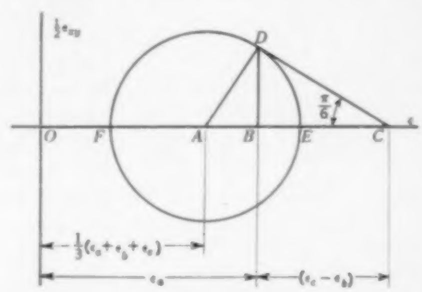

FIG. 4. MOHR CIRCLE DIAGRAM CONSTRUCTED FROM EQUIANGULAR STRAIN-ROSETTE DATA

A Simple Curve-Ranging Instrument

By F. F. FERGUSSON, ASSOC. M. AM. SOC. C.E.

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THE curve-ranging instrument described here may prove of interest to civil engineers engaged in laying out curves for road, canal, or railroad location. In its most rudimentary form it is sufficiently accurate for trial location, and it could be improved to do exact work.

The principles upon which it depends are simple. In Fig. 1, α is the angle of intersection of the tangents TI and $T'I$, and R is any point on the circular arc. The angle β in the segment TRT' is constant, and it is easy to prove that $\gamma = \frac{\alpha}{2}$ for any circle which may be drawn to touch the two tangents. If a mirror be set at R, with its plane perpendicular to the line bisecting the angle γ, and its reflecting surface remote from T, rays of light traveling in the direction $T'R$ will strike the mirror and be reflected back in the direction of TR extended.

The instrument itself is shown in Fig. 2. Observation slots provided with vertical sighting hairs (black threads answer well) are placed at A and A'; and the mirror, mounted perpendicular to the plate, can be set at any desired angle to the diameter passing through the slots. If the mirror is given a deflection of delta $= \frac{\gamma}{2} = \frac{\alpha}{4}$, the center of rotation of the mirror can be placed exactly on the curve by moving the instrument until the reflection, in the mirror, of a range pole at T' coincides with a range pole sighted at T through the observation slits A' and A—that is, until the reflection of the pole at T' appears to be a continuation of the lower part of the pole sighted at A.

In setting out a curve, the angle α is measured, the tangent distances are computed from the equation $IT = R \tan \frac{\alpha}{2}$, and range poles are set at T and T'. The curve can then be ranged by sighting the range pole

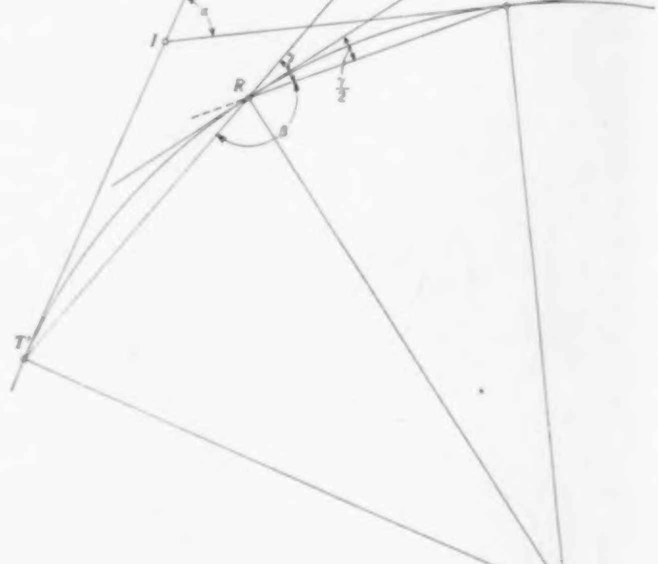

FIG. 1

at T and getting that at T' coincident with it in the mirror. This involves only a slight lateral shift either way on the part of the surveyor, once sufficient familiarity has been gained to allow him to set himself close to the actual line.

If the instrument is set on a table with a slot in it, through which a plumb line can be dropped, the work is considerably facilitated and is more accurate than if the instrument is held in the hand.

The writer has had two of these instruments made in the departmental workshop, and has used them in setting out curves for construction work on seventy miles of channel and on maintaining the center line in the foundation trench of an arch dam with considerably less expenditure of time than would be required with any other method known to him. In fact it was the necessity of getting an immense amount of work through in a very short time that led him to search for a rapid method of setting out curves, which could be entrusted to subordinates.

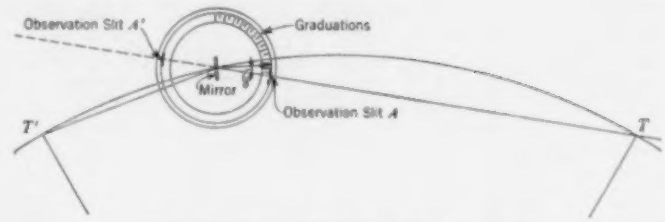

Fig. 2. Curve-Ranging Instrument

Diagonal Bending of Square Concrete Sections

By Paul Andersen, Assoc. M. Am. Soc. C.E.
Assistant Professor of Structural Engineering, University of Minnesota, Minneapolis, Minn.

Precast concrete piles are generally lifted in such a way that one diagonal of the square cross-section becomes horizontal. In this position the bending moment to be resisted by the section will act in a plane through the vertical diagonal. Compressive stresses thus set up will reach a maximum at the apex and can be computed from the bending moment as explained in this article. Diagonal bending will also occur in corner columns subjected to equal moments in two directions; the formulas developed below can be used for such cases provided the bending moments are not accompanied by any direct thrust.

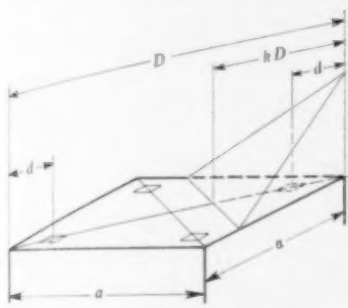

Fig. 1

The equations expressing the relationship between stresses and diagonal bending moment as presented in this article are based on the usual practice of reinforced concrete design, namely, preservation of plane sections, proportionality between stress and strain, and disregard of tensile stresses in concrete. The following symbols are used:

A_s = cross-sectional area of one reinforcing bar
a = side of square
C = coefficient of resistance
D = length of diagonal
d = distance from corner to reinforcing bar
f_c = maximum compressive stress in concrete
f_s = maximum tensile stress in reinforcing bars
k = distance from apex of compression area over length of diagonal
M = bending moment, in pound-inches
n = ratio of moduli
p = steel ratio, $4A_s \div a^2$

Derivation of Formulas.—A square concrete section reinforced with four steel bars of equal cross-sectional area is shown in Fig. 1. If this member is subjected to the influence of a bending moment acting in a plane through the two opposite edges, then the neutral axis will be parallel to the diagonal connecting the two other corners. The position of the neutral axis can be determined by equating the sum of all the internal stresses to zero, thus:

$$\frac{f_c}{3}(kD)^2 + \frac{kD-d}{kD}f_c(n-1)A_s - \frac{1-2k}{k}f_c nA_s - \frac{D-kD-d}{kD}f_c nA_s = 0 \quad [1]$$

Substituting $pD^2/8$ for A_s in Eq. 1, and dividing by $\frac{f_cD^2}{24}$ gives

$$8k^3 + 3p\,(4n-1)k - 3p\left(2n - \frac{d}{D}\right) = 0 \quad [2]$$

and as d/D will always be very small compared to $2n$, Eq. 2 may be written

$$k^3 + \frac{3}{8}p(4n-1)k - \frac{3}{4}pn = 0 \quad [3]$$

Figure 2 gives the relationship between k and p for values of n equal to 10, 12, and 15.

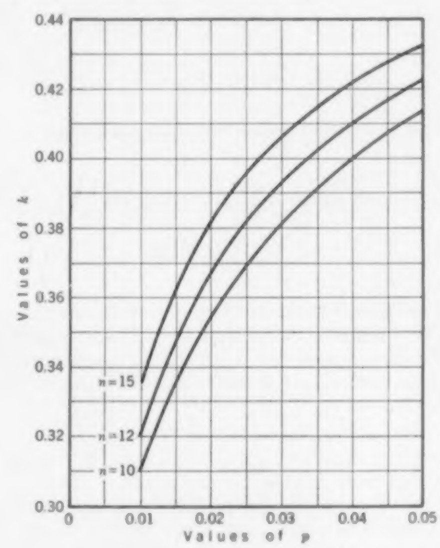

Fig. 2. Relation Between k and p for Various Values of n

The maximum compressive stress in the concrete can be found by taking moments about the diagonal parallel to the neutral axis. Neglecting the slight reduction in

the compression area caused by the presence of the steel gives

$$\frac{f_c}{3}(kD)^2\frac{D-kD}{2} + \left(\frac{D}{2} - d\right)nA_s\left(\frac{kD-d}{kD} + \frac{D-kD-d}{kD}\right)f_c = M \quad \ldots [4]$$

Solving,

$$f_c = C\frac{M}{D^3} \quad \ldots\ldots [5]$$

Where

$$C = \frac{6k}{k^3(1-k) + \frac{3}{2}pn\left(\frac{1}{2} - \frac{d}{D}\right)^2} \quad \ldots\ldots [6]$$

Values of C are plotted in Fig. 3 for a ratio of embedment, d/D, of 0.20. For other values of d/D, similar diagrams can be prepared. To provide for various values of n, the quantity pn is used as an argument instead of p.

Maximum tension will occur in the bar most distant from the neutral axis and will equal

$$f_s = f_c n\left(\frac{1-k}{k} - \frac{d}{kD}\right) \quad \ldots\ldots [7]$$

Numerical Example.—A square concrete pile, 15 in. by 15 in. by 60 ft 0 in. long is reinforced with four 1 in. square bars, the distances from the centers of these bars to the corners being 3 in. What are the maximum compressive and tensile stresses if this pile is lifted by placing slings around it at the fifth points? Assume $n = 15$.

Using $p = 4 \div 225 = 0.0178$, Fig. 2 gives $k = 0.374$. The value of pn is $15 \times 0.0178 = 0.267$. With k and pn known and $d/D = 0.2$, C can be computed from Eq. 6 or found from Fig. 3. The maximum bending moment is

$$\frac{15 \times 15}{144} \times 150 \times 12 \times 6 = 16{,}850 \text{ lb-ft} \quad \ldots [8]$$

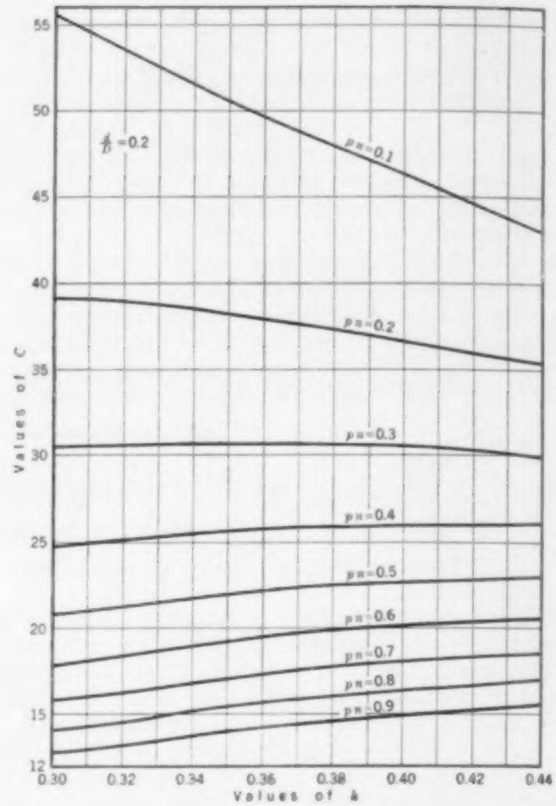

FIG. 3. RELATION BETWEEN C AND k FOR VARIOUS VALUES OF pn, FOR $d/D = 0.2$

The stresses are

$$f_c = 32.7 \times \frac{16{,}850 \times 12}{21.2^3} = 693 \text{ lb per sq in.}$$

and

$$f_s = 693 \times 15 \times \left(\frac{0.626}{0.374} - \frac{0.200}{0.374}\right) = 10{,}550 \text{ lb per sq in.}$$

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Use of Surface Water for Municipal Purposes

TO THE EDITOR: In connection with Mr. Pirnie's paper on "Treatment of Florida's Artesian and Surface Water Supplies," in the May issue, I should like to describe a rather unusual water supply system that has recently been completed in Pinellas County, Florida.

Along the west side of Pinellas County, separated from the mainland by Clearwater Bay and Boca Ceiga Bay, is a chain of islands varying in width from 150 ft to half a mile. The population of these islands has been increasing rapidly, and the only water available was a small system in the town of Pass-A-Grille. However, the wells supplying this system had such a large salt content that the water was not fit for human consumption.

Thus a water district was created in order to supply good water to these islands all the way from Indian Rocks to Pass-A-Grille, a distance of about 18 miles. This new system is unusual in that it consists of a single water main with a few branches at locations where the island is wide enough for more than one or two streets. It was difficult to find a satisfactory source of supply. Test wells were driven in the territory north and west of St. Petersburg, and in no case was a sufficient supply found. It was finally decided to use surface water from McKay's Creek at a point about two miles east of Indian Rocks along an east and west county highway. This meant that the water for Pass-A-Grille would have to be pumped about twenty miles.

McKay's Creek, at the place selected, is a very sluggish stream, having more the appearance of a swamp than a creek. At the point of raw water intake, it had a flow of about 400 gal per min during a normal or average rainfall period. After a prolonged dry season of from forty to sixty days there was no apparent flow at all. The color of the water averages about 130.

At the present time this water system is supplying the equivalent of about 600 consumers, and the supply appears to be ample for at least 1,500 consumers. After this number is reached, it will be possible to develop additional reservoirs at available locations above the one now in use.

The water is treated with aluminum sulfate and carbon. After treatment it is allowed to settle and is then passed through sand filters. Lime is added to the water after it passes the filters in order to increase its alkalinity. When the treated water is pumped into the distribution system, it is chlorinated and ammonia sulfate is added.

The result of the mixing and treatment is to raise the pH from $7^1/_2$ to 9, reduce the color from 130 to 10, and raise the permanent hardness from 62 to 84. Since this plant is new and still in the experimental stage, treating and pumping cost records have not been kept long enough to be reliable. The chemicals now in use cost 1.9 cents per thousand gallons. The total pumping and treating cost, not including debt service, is now $11^1/_3$ cents per thousand gallons.

Although this plant is small and uses only ordinary methods of treatment, it does demonstrate in a small way the possibility of developing surface water supplies for human and industrial consumption at locations where sufficient water apparently does not exist.

JOHN F. REYNOLDS, M. Am. Soc. C.E.
Consulting Engineer

Jacksonville, Fla.

The Pacific Coast Tackles the Pollution Problem

DEAR SIR: In his article in the July issue, Mr. Fisher has referred to the effect of sulfite pulp wastes in the Puget Sound area, where the principal oyster fields of the Pacific Coast are located. The State of Washington Health Department has inaugurated publicity and strict law enforcement that safeguard the sale of oysters from affected fields. Anticipated new sulfite pulp plants will make this problem more acute, and an active interest is being shown in the treatment of these wastes.

The salmon runs in the northern coastal streams are seriously menaced by pulp wastes as well as by municipal sewage, and this condition has probably aroused more public sentiment in favor of adequate disposal methods than any other one thing.

The menace to fish life, particularly to the large fish, from sludge deposits exerting a high bio-chemical oxygen demand, even when the deposits occur in streams with generally adequate dilution factors, has been little discussed. A classic example came under my observation on the Klamath River in southern Oregon, some distance below the city of Klamath Falls, which was discharging untreated sewage into the river. In the fall of 1928, when the river flow was low, great numbers of large steelhead were found dead. A survey by the State Board of Health indicated that there were heavy sludge deposits in the deep pools, and that the stream was devoid of oxygen immediately above these deposits even though it was from 80 to 100 per cent saturated at the surface. It should be added that, following the construction of adequate sewage treatment works the following year, no further reports have been made of fish dying.

San Francisco Bay, once the home of a considerable oyster industry, no longer has important fields. Studies that I made in 1912 indicated that diatomaceous life had been so greatly depleted, probably from the pumping out of oil tanker ballast water in the bay, that oysters could not get sufficient food. While sewage contamination has played a part in the destruction of the industry, oil and similar industrial wastes have been the real contributing factor.

The sewage and industrial wastes from the inland cities of Stockton and Sacramento adversely affect the fish runs in the two large interior valley rivers. The huge vegetable and fruit canning industries in this region have wastes with high oxygen demands. Studies made by my office in 1936 at Stockton indicated that the combined municipal and industrial wastes, largely from fruit and vegetable canneries, exerted a bio-chemical oxygen demand on the San Joaquin River equivalent to that of a population five times greater than that of the city.

In southern California there are no large coastal streams. Pollution of beaches is primarily a health menace to recreational areas rather than to fish life, although occasional illegal dumping of oil no doubt affects surf fishing.

The solution of the pollution problem lies in arousing public opinion to demand control measures, and courageous public officials to enforce the law. With the possible exception of sulfite wastes, our present knowledge is sufficient to enable us to build plants capable of treating our industrial and municipal wastes so that they will not be a hazard to fish life.

The rapid growth of pollution on the Pacific Coast may actually be a means of checking it, since the depletion of fish life is so recent and marked that public opinion is demanding curative measures. Seattle, Portland, San Francisco, Oakland, Los Angeles, and San Diego are all either building new sewage treatment plants or have active plans toward their construction.

CLYDE C. KENNEDY, M. Am. Soc. C.E.
Consulting Engineer

San Francisco, Calif.

The Florida Mapping Project

TO THE EDITOR: Mr. Barnhart's paper on the "Progress and Control of Mapping in Florida," in the June issue, is a noteworthy exposition of the many surveying and mapping problems that have confronted Florida engineers for years. However, these problems have not been experienced by Florida engineers alone. In most sections of the United States the absence of survey and map data is keenly felt, and so it may be said that Florida engineers and others interested in surveying and mapping in general have much the same interest in the subject as engineers in other sections of the country. The many articles and discussions that have appeared in CIVIL ENGINEERING are indicative of the lively interest in this subject, and it should be noted that these articles and discussions have been almost wholly in support of a nation-wide surveying and mapping plan.

Little need be said of the many purposes for which adequate horizontal and vertical control data and topographic maps may be used. Suffice it to say that on the average and over a period of time, the communities lacking such data are paying more for not having these data available than the cost of producing them would be.

Except for a brief period of a few weeks, the work of the Florida Mapping Project has continued from its inception in November 1933 to the present time. Through close cooperation with the U. S. Coast and Geodetic Survey, this organization has undertaken the completion of triangulation arcs. When these are completed, no place in Florida will be farther than 25 miles from a triangulation station except in the Everglades area.

In 1934 the Florida Mapping Project, in addition to its work of triangulation traverse and leveling, initiated a program of topographic mapping. In this connection, the U. S. Geological Survey has rendered invaluable assistance by cooperating to make the work meet their standards and to publish the quadrangle maps when completed and when funds become available.

Florida engineers and others interested in securing control data and topographic maps are proud of the work accomplished by this organization. The Florida Mapping Project is now sponsored by the State Planning Board and is financed and carried on by employees of the Works Progress Administration. From the beginning it has increased the scope of its work to supply the kinds of surveying data most needed in this state. Because of what has already been achieved and the efficiency of the organization, it is to be hoped that the project will continue until all its objectives are realized.

These objectives may be summarized as follows:

1. The completion of the 25-mile spacing of arcs of triangulation in Florida.
2. The adequate placement of local control stations, consisting of second- and third-order traverse between triangulation stations—each monument to serve also as a bench mark for third-order levels.
3. The completion of the topographic map of Florida in quadrangle units.
4. Publishing maps and data on control.
5. Making available the data on rectangular plane coordinates for use as legal descriptions for land surveys.

WILLIAM L. SAWYER, Assoc. M. Am. Soc. C.E.
Assistant Professor of Civil Engineering, University of Florida

Gainesville, Fla.

The Engineer and Architect Should Cooperate

DEAR SIR: I was interested in Mr. Watson's article on "Architectural Principles of Bridge Design," in the March issue. In the last analysis the architect is trained in matters of design for abstract beauty, whereas the structural engineer is trained for matters of design based on economy of use of material and physical strength. What is needed, then, is close cooperation between the two, each recognizing the particular forte of the other. The result of such a combination should be a bridge which would be at once economical and structurally strong and yet have an abstract shape and proportion, beautiful to look upon.

When it comes to matters of beauty, each has his own idea. Personally I do not appreciate what is commonly known as "modernistic." A purely egg-shaped form, which is structurally perfect, is not pleasing to me. Beauty, therefore, is a matter of opinion. The public—not of this generation but of future generations—will determine whether what this generation does is beautiful or not, irrespective of the opinions of this generation.

The article by Mr. Watson well illustrates changing opinion, not only in bridge construction but in architecture. The last photograph in the article, "Bridge Over Bixby Creek, California Coast Highway," is illustrative of modern lightness as contrasted with heaviness in the first photograph, "Bridge of Augustus at Rimini." However, I think it would be unwise to make a cold statement as to which is more beautiful. Both are excellent for their generation and time.

CASS GILBERT, JR.
Architect

New York, N.Y.

Policies and Prospects in National Mapping

TO THE EDITOR: I feel that the members of the Society and other readers of CIVIL ENGINEERING will be glad to get some additional information on the matter of a national mapping program.

The Society has consistently supported mapping on a large scale by the federal government. This is indicated by the creation in 1926 of a Division of Surveying and Mapping and also by a number of resolutions that have been adopted by the Society dealing with national mapping.

Some progress was made in national mapping during the past few years by the use of Public Works Administration funds allotted to the Coast and Geodetic Survey and to the Geological Survey. However, in 1935 the allotment of funds from this source was discontinued and little or nothing has been done in national mapping since, largely owing to a curtailment of the regular appropriations to the bureaus.

The President of the United States has been requested by individuals and organizations to initiate the so-called Ickes plan, which calls for a hundred million dollars to be spent on national mapping during the next twenty years. In his replies to those communications he has expressed the view that the inauguration of a national mapping plan should await action by Congress on reorganization. The bill that was before Congress calling for reorganization of the administrative branch of the government did not pass. It is hoped he will not longer delay his endorsement of national mapping.

It seems incomprehensible to engineers that mapping should not have been made one of the major public works to be carried on by the funds that have been appropriated by Congress during the past few years for pump-priming. There is no class of engineering work that is more important than to make an inventory, on sheets of paper called maps, of the physical facts of the earth's surface. Again there is no engineering work in which so large a percentage of the personnel must be of a technical character. There will be many graduates in engineering at the end of this college year who will find difficulty in getting employment. Why not start a national mapping plan and put young engineers to work on real engineering jobs rather than let them drift into non-professional work or perhaps on to the relief rolls?

This letter may seem pessimistic, but I still feel encouraged by the tremendous sentiment that exists among map makers and map users throughout the country. Surely this sentiment will be translated into action at some time in the not distant future. In the meantime the map users back in the home districts will have to make their wants known by communicating with high officials of the federal government and of their local governments. If the map user does not urge national mapping, he cannot blame officials for not inaugurating a national mapping plan.

WILLIAM BOWIE, M. Am. Soc. C.E.
Hydrographic and Geodetic Engineer,
U. S. Coast and Geodetic Survey (Retired)

Washington, D.C.

Recent Improvements on St. Johns River

TO THE EDITOR: The early history and the successful improvement of the St. Johns River have been ably presented by Colonel Youngberg, in the June issue, but I think that it may be of interest to mention a few of the more recent improvements that have proved beneficial in decreasing the cost of maintaining this waterway.

The general alinement of the present channel adheres closely to the natural deep water. The channel has been improved by deepening and widening, with additional widths at the bends varying from 600 to 1,200 ft. The gorges and bends have been adjusted so as to produce as nearly as practicable a uniform current velocity throughout the reach of the river from Jacksonville to the ocean. This has retarded scouring in the congested sections and reduced the amount of material deposited in the more open reaches, thus materially reducing maintenance dredging. The widening of the bends, in addition to securing more uniform current velocities, has been very beneficial to navigation.

By reference to Colonel Youngberg's Fig. 1, it will be seen that straightening the lower stretch of the river by making cutoffs would improve the alinement and shorten the distance from Jacksonville to the ocean. It has been decided, however, that the benefits to be derived would not justify the expense. The dimensions and location of the present improved channel amply provide for present and prospective commerce.

The construction of Ward's training wall and revetment, to which Colonel Youngberg refers, has resulted in straightening the channel through this stretch of the river and eliminating the troublesome shoal that previously formed along the north side of the channel. Minor shoals, however, continued to form along the channel between the jetties, as a result of eroding material drifting through both jetties. To arrest this movement of sand through the south jetty, the voids in the jetty were filled with one-man granite to a point about 4 ft above low water.

The fill along the north jetty, and south of Fort George Inlet, continues to erode, exposing the jetty shoreward. To arrest movement of sand through the north jetty, a concrete monolithic cap was constructed in 1934. This work involved the placing of 3,780 cu yd of concrete, rectangular in shape and about 7 ft high. From the shore line westward for about 600 ft the concrete was 2 ft wide on top, entirely on land, and from 3 to 4 ft in depth. From the shore line seaward, the cap was 6 and 8 ft wide. The total length was 3,555 lin ft. The concrete was composed of one part cement, three parts local beach sand, and five parts gravel. The voids in the jetty below the 4.0-ft elevation were plugged with one-man stone, the concrete being deposited on the smaller stones as a base and confined in a rectangular shape by means of forms. Expansion joints were not considered practical because of the presence of the large jetty rocks within the concrete area.

Since the completion of the work the shore line has receded about 500 ft westward, and work is now in progress to extend the concrete cap westward about 600 ft. The condition of the channel indicates that there is little movement of sand through the jetty except as erosion occurs west of the concrete cap.

The channel from Jacksonville to the ocean is now so stabilized as a result of the dredging, involving widening and deepening, and the control works provided by the training walls, revetment, and jetties, that one dredge operating only part time adequately maintains the channel, whereas one to three dredges were formerly employed in the operation.

EARL NORTH
Lt. Col., Corps of Engineers, U. S. Army; District Engineer, U. S. Engineer Office

Jacksonville, Fla.

The Intersection of Cylinders

DEAR SIRS: The article by A. W. Lambert, in the April number, regarding the analytical method for finding the intersection of two cylinders was read with much interest and some amazement. Amazement, first, that an analytical method should be considered faster than a graphical one—admitting that for extreme accuracy it may be more desirable; and second, that a method as cumbersome and formidable as that suggested should be considered necessary.

This problem is typical of many three-dimensional settings which can be broken down into two or more two-dimensional views by the methods of descriptive geometry and easily solved in those views. They can then be reassembled in the space setting for the required analytical equations. Consider two cylinders of radii R and r, parallel to the X–Z (horizontal) plane (Fig. 1). Cylinder

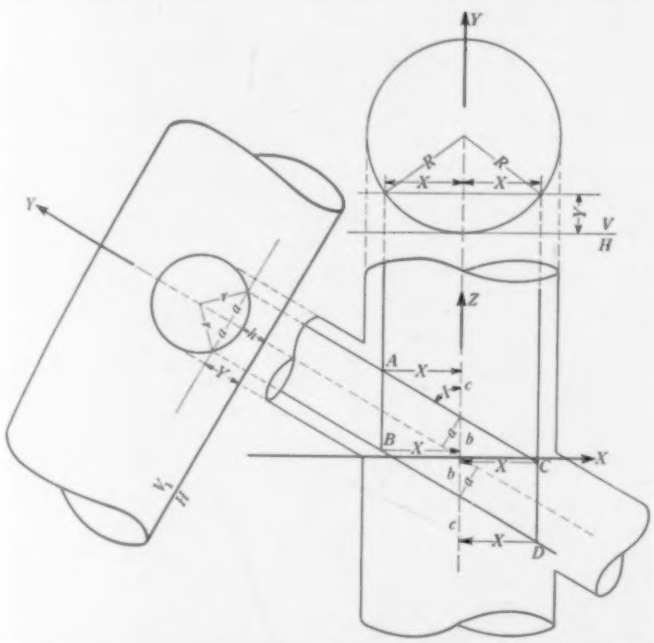

FIG. 1. SHOWING THE INTERSECTION OF CYLINDERS THAT ARE NOT TANGENT TO A COMMON PLANE

R is tangent to that plane and cylinder r is at a Y-distance h above it. Let I be the angle of incidence of the cylinders. This is the general case regardless of complete intersection.

First, solving by methods of descriptive geometry for points A, B, C, and D as points of intersection of elements on the two cylinders cut by an auxiliary horizontal plane at the elevation Y, and then transforming the graphical setting into algebraic symbols, we obtain the relatively simple equations for the intersection of the cylinders, thus:

Assume Y as the independent variable. From the view on plane V we obtain, $X^2 = R^2 - (R - Y)^2$ or $X = \sqrt{Y(2R - Y)}$. From the view on plane V_1 we obtain, $a^2 = r^2 - (r + h - Y)^2$. From the view on plane H we obtain, $b = \dfrac{a}{\sin I}$, $c = \dfrac{X}{\tan I}$, $Z = c \pm b$. Therefore, assuming values for Y, the equations of the intersection are $\pm X = \sqrt{Y(2R - Y)}$ and $Z = \dfrac{\pm X}{\tan I} \pm \dfrac{\sqrt{r^2 - (r + h - Y)^2}}{\sin I}$. This locates four points, A, B, C, and D at the elevation Y. If Y be assumed less than h, or greater than $h + 2r$, the second term in the expression for Z becomes imaginary, therefore Z is imaginary, and there are no points. In the position of partial intersection, if Y be taken greater than $2R$, or less than zero, X becomes imaginary and there are no points. This solution is the general case. If slide-rule accuracy is sufficient, points can be located rapidly from these equations.

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University of California

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Saline Infiltration in Florida Wells

TO THE EDITOR: Inspired by Mr. Stringfield's article on "Ground-Water Supplies in Florida" in the July issue, I should like to outline some actual experiences encountered there.

During the process of modifying the three old municipal 8-in. wells in Sarasota, we found that these wells were cased down only 12 ft to cap rock. Similar situations exist in a great many other wells in the state, and this naturally results in great losses of yield and pressure from the underlying artesian basins, as the casings do not extend to sufficient depth to thoroughly seal off the wells. We extended the casings of the wells in question and plugged them at approximately the 500-ft level. Although all three wells were modified in much the same manner, the results that we obtained varied greatly.

Well No. 1 now gives a raw water of approximately 48 grains per gallon total hardness, as $CaCO_3$; but the flow from this well has been halved, and in order to obtain 175 gal per min of this softer water it has been necessary to install a deep well pump capable of operating when the drawdown in the well is 50 ft.

Well No. 2 gives a raw water of approximately 52 grains total hardness, as $CaCO_3$, and the flow from this well has been so greatly reduced that it is barely possible to obtain 350 gal per min, with a drawdown of 50 ft.

Although Well No. 3 was modified in exactly the same way, it shows no change in the quality of the raw water, retaining a hardness of 65 grains, and the original flow from this well has not been greatly impeded by the modification—600 gal per min with a 25-ft drawdown.

For fire protection purposes, the City of Sarasota has drilled two additional 8-in. wells, each cased only approximately 20 ft (to cap rock only). These wells are from 650 to 675 ft deep producing raw water of between 65 and 70 grains total hardness, but they yield 500 to 600 gal per min, with a drawdown of only 15 to 20 ft.

Two of the modified wells seemingly have no connection with the deeper wells, as the quality of the water and the available head are different. All of the Sarasota municipal wells are within approximately 300 ft of each other, however. This leads me to believe that the principle of equilibrium between salt and fresh water as applied to the hydrology of the seacoast cannot be applied to the particular subsurface conditions existing in Florida, as there are evidently impermeable layers interposed between the various rock strata and the sea water of the ocean and the bays overlying these strata.

The extensions of the casings in the old Sarasota wells resulted in some reduction of fluorides, according to one laboratory, and in a slight increase in fluorides, according to another laboratory. The method of making this fluoride determination and the bias of the individual laboratory evidently were great factors in arriving at the reported results.

Another interesting development, at this time, is the deep-well situation in Fernandina, Fla., where five 18-in. pumped deep wells, which are properly cased to, and deep into, bedrock for 700 ft of their total depth of 1,000 ft, are delivering 30,000,000 gal of water per day. The older wells in this vicinity are naturally being drawn down—in some cases to such an extent that pumps are necessary. This excessive drawdown has not resulted in any increase in chlorides, however, and some of the wells are within 500 ft of saline water.

To my mind this indicates that there must be some interconnection between all the wells involved and that there must, also, be a layer of impermeable material under the saline water in nearby rivers, overlying the limestone strata that form the artesian basin. Seemingly, however, there is no interconnection between the saline water and the wells. The results of our work in Fernandina and Sarasota lead me to believe that the straight-line relationship between artesian head and saline infiltration must be modified in the case of Florida artesian supplies to take into account other complicating factors. As for fluorine and fluoride investigations, the problem of getting any two outstanding laboratories to agree must first be solved before definite statements are made as to the seriousness of this problem in any particular locality.

CHARLES E. RICHHEIMER, Assoc. M. Am. Soc. C.E.

Jacksonville, Fla.

SOCIETY AFFAIRS

Official and Semi-Official

The Sixty-Eighth Annual Convention

Salt Lake City Is Scene of Mid-Summer Society Meeting

MORE THAN 400 members and guests were registered at the Sixty-Eighth Annual Convention of the Society, which closed at Salt Lake City, Utah, on July 23, after a four-day session. For a city of its size, in the center of a large region of mining and agriculture rather than of industrial and urban development, this attendance was indeed gratifying. In fact, the entire Convention was on a similar large scale of value and interest. On the program were meetings of four Technical Divisions and a wide variety of social events.

PRESIDENT RIGGS AND R. A. HART, PRESIDENT OF THE UTAH SECTION, DISCUSS DETAILS OF THE PROGRAM

Feature of the opening session on Wednesday morning, July 20, was the annual address, delivered by President Riggs, on the relation of the national Society to the engineering profession. An abstract of this address is presented as "Something to Think About" on page 507 of this issue of CIVIL ENGINEERING, and the full text will appear in the 1938 TRANSACTIONS.

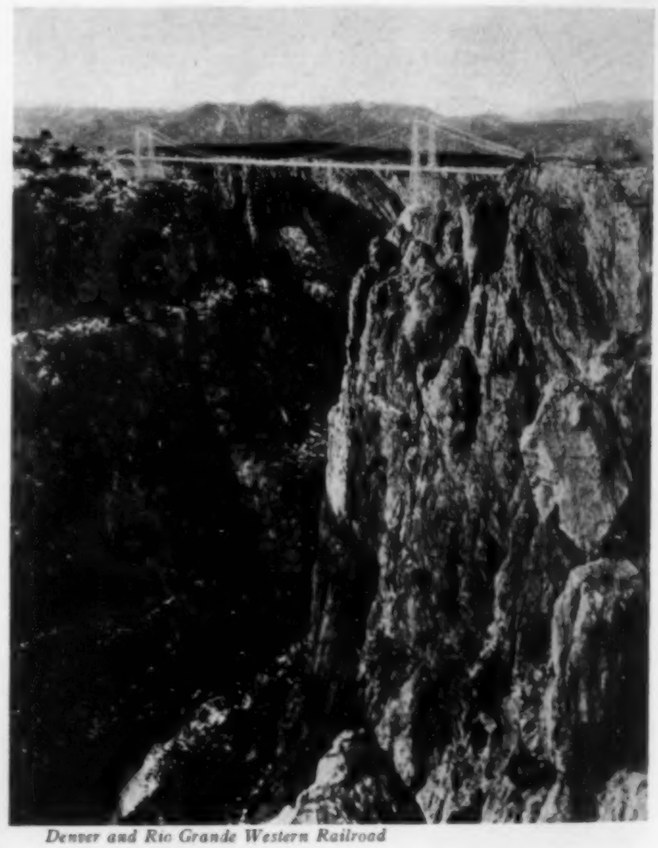
A comprehensive symposium on transportation made up the technical program for the first day. Following a general review of recent advances in transportation, with its keen analysis of the various engineering factors involved, four speeches presented individual aspects of the subject, covering the fields of rail, highway, and air transportation. One of the two papers on rail transportation, announcing the development of a steam turbo-electric locomotive, is abstracted in this issue.

Climax of the social events was a dinner and entertainment on Wednesday evening at the Hotel Utah, headquarters of the Convention. Two addresses of a non-technical nature made up the program; the first, historic reminiscences by one of the pioneers, and the other an illustrated address showing the various scenic features of southern Utah.

PRE-CONVENTION ACTIVITY
Vice-President Goudy and Past-President Mead (Seated) Go Over Plans with R. K. Brown, Chairman of the Entertainment Committee

Technical sessions occupied the entire day on Thursday, July 21. In the morning the Surveying and Mapping Division heard two papers on the status of mapping in the western states, and two on the technique and value of aerial mapping. Simultaneously the Irrigation Division and Highway Division were also in session. The program of the former included a historical paper on irrigation in Utah and papers on the Deer Creek project and the development of the Colorado River. The highway engineers concerned themselves with problems in state-wide highway planning and methods of levying and apportioning taxes for highway purposes. The paper on the latter subject appears in this issue.

In the afternoon the Sanitary Engineering Division sponsored a program of three papers on sewage and garbage disposal. The first of these discussed the specific needs of the western states; the second described the new sewage treatment plant at Denver, and the third was a review of modern incinerator practice.



Denver and Rio Grande Western Railroad

ON THE ROUTE OF THE PRE-CONVENTION TOUR—THE ROYAL GORGE, GRAND CANYON OF THE ARKANSAS RIVER, COLO.

The Irrigation and Highway Divisions both convened for afternoon sessions also. The former included a report on the activities of the Committee on Conservation of Water, and papers on irrigation in China, drainage of irrigated lands, and the relation between flood control and water conservation. On the Highway Division program were papers on highways from the users' standpoint and the value of highways in floods, which appear in this issue, and a description of a recently developed coordinate system of street and highway numbering.

One of the more intimate and friendly social events of the Convention was the dinner and dance at the headquarters hotel on

Thursday evening. It was characterized by the pleasant informality of the West, made even more enjoyable by the acquaintanceships developed as the Convention progressed.

On both Wednesday and Thursday the ladies were entertained with shopping and sightseeing tours and special events. A luncheon at the Salt Lake City Country Club and a special organ recital at the Tabernacle were outstanding events on their program.

An all-day excursion to the copper mines at Bingham and the mills at Garfield and Arthur attracted a large number of both men and women on Friday. The return to Salt Lake City was timed so that those who wished to could attend the Rodeo that is held in connection with the "Pioneer Days" celebration.

Saturday the Convention was brought to a close with a number of inspection trips to points of engineering interest. Members and their guests could choose between a tour through the Davis County watershed to study flood and erosion control projects, and a visit to the Ogden River Irrigation District and the Mountain Dell Reservoir of the Salt Lake City water supply system.

Among the Ladies Were Mrs. Howard C. Means, General Chairman of the Ladies' Committee, Mrs. Henry E. Riggs, and Mrs. R. C. Gowdy

Though the Convention proper opened on the 20th, the preceding day was a busy one for many members. An all-day conference sponsored by the Utah Sectional Committee on Water Conservation and held under the auspices of the Utah Section attracted an attendance of over 100. A conference of representatives of the 11 Local Sections in the Western Meeting Region, with Board members and many others interested, was held throughout the same day for discussion of topics of professional interest. And, finally, student members attended a joint luncheon with members of the Board of Direction and others.

Arrangements for the Convention gave evidence of careful preparation. None of the features, whether of a technical or a social nature, whether for the entire membership, the Divisions, or the ladies, was slighted. The result was a full measure of enjoyment for the visitors and a similar degree of satisfaction for the local hosts. For this fine showing all committees deserve great credit.

Quite a group of members and their families took advantage of the pre-Convention tour, which gave them an opportunity to travel together from Chicago, via the Burlington Zephyr, to Denver. Thence they went to Colorado Springs, where a day was spent in sightseeing before the final lap of the journey began. The party arrived at Salt Lake City on Sunday, July 17.

New Publicity Program for Society

As of July 1, 1938, the Society is undertaking an intensification of its program of publicity, or public information, on behalf of the profession. With this end in view, two additions have been made to the staff at Society Headquarters.

In charge of national publicity is George A. Miller. Working through newspapers throughout the country, Mr. Miller's aim is to picture the value of the engineer to the community through stories about the quarterly meetings, the people attending them, and the papers presented. He will also supply the various news services with popularized abstracts of those articles appearing in the Society's publications which have especial news interest.

Local publicity in all parts of the country, originating with the various Local Sections, is also being encouraged, and Miss Josephine K. Scott has been selected to handle this phase of the work. She will collaborate with the publicity committees of the Sections in an effort to develop engineering news of special local interest, for publication in local papers.

This redevelopment of the publicity program is to the credit of the Committee on Public Information, whose members are William H. Adams (chairman), T. R. Kendall, Harry L. Kinsel, E. O. Sweetser, and James K. Finch, contact member from the Board of Direction.

Fall Meeting to Be at Rochester, N.Y., October 12–15, 1938

Plans for the 1938 Fall Meeting, which will be held in Rochester, N.Y., October 12–15, are rapidly being completed. Not only does the program have an unusually wide technical interest, but it offers also the opportunity for visiting a number of manufacturing plants of particular interest to engineers.

The meeting differs from the usual Society meeting in that the Technical Divisions have taken the responsibility for the entire technical program. For the opening session on Wednesday morning, October 12, the Structural Division has arranged for a paper commemorating the 300th anniversary of the beginning of modern structural theory. This paper is being prepared by S. C. Hollister, M. Am. Soc. C.E., dean of the College of Engineering, Cornell University, and will outline the advances in structural analysis over the past three centuries.

On Wednesday afternoon the Structural Division and the Waterways Division will hold simultaneous sessions. The program of the former will consist of a number of papers dealing with the design and construction features of the Thousand Islands Bridge, and the New York Central grade-separation project at Syracuse. The Waterways Division program is to be made up of a number of papers on the recent flood control studies and works for New York State rivers. It is expected that these papers will cover all the studies that have been made, including those by means of hydraulic models, and the results of operations to date.

The Technical Division sessions will continue on Thursday and Friday mornings, October 13 and 14, with local excursions in the afternoons. The Power Division program for the two days will be a symposium on progress in power plant design and efficiency, and will cover various technical aspects—such as the trend in power house space limits and equipment costs in relation to head, size of units, and total kilowatt installation; power plant design and efficiency from the owner's viewpoint; and preliminary selection of hydraulic turbines and power house dimensions. The Soil Mechanics and Foundations Division likewise has arranged a program occupying Thursday and Friday mornings, with papers on the application of soil mechanics in substructure problems, settlement studies of structures, and soil studies at the Muskingum Conservancy District and at Fort Peck.

The Sanitary Engineering Division will convene on Thursday morning to discuss progress in the control of water pollution in New York State and to hear papers dealing with the Syracuse sewage project and the Buffalo sewage treatment plant. On Friday morning, the City Planning Division will be responsible for a symposium on traffic control for urban communities; the subject will be considered from both engineering and police-control aspects.

The inspection trips that have been arranged for Thursday and Friday afternoons are of great attractiveness to engineers and to the ladies as well. One of these excursions is an extensive trip through the plant of Eastman Kodak Company, on which members and guests will be able to see many of the interesting and unique operations of this vast enterprise. Another trip of particular significance to engineers is the inspection of the Bausch and Lomb Optical Company, manufacturers of optical and scientific instruments since 1853; and a third trip of special appeal will be to the plant of the Taylor Instrument Company, which makes more than 8,000 different instruments for the measurement or control of temperature, pressure, specific gravity, and so forth. Few plants utilize a greater diversity of arts and crafts.

The Rochester Committee on Arrangements, aside from providing a program of technical meetings and excursions of exceptional interest, has given careful attention to the social features. Plans for entertainment as at present developed call for a dinner and dance at the Hotel Seneca on Wednesday evening, October 12, and an informal entertainment on the following night. Affairs for the ladies include luncheons and teas, an all-day excursion to either Niagara Falls or the Bristol Valley and Canandaigua Lake, and shorter sightseeing and inspection trips in and around Rochester.

Those who wish to stay over through Saturday to complete their inspection of points of engineering interest in Rochester and vicinity may be assured of full cooperation of the Rochester committee in seeing that their wishes are fulfilled. The committee deserves the highest praise for the thoroughness with which it has handled all phases of the arrangements for this meeting.

Indiana Section Goes Picnicking

THE ANNUAL picnic of the Indiana Section, held in conjunction with the summer school in surveying of Purdue University, took place on Sunday, July 17, at Ross Camp, south of Lafayette. Despite a steady rain, which continued throughout the day and made it necessary to have the games and contests indoors, a profitable and pleasant time was had by the Section members, their families and guests.

Following the dinner, which was served in the mess hall at the camp, there was a business session of the Section. Dean R. B. Wiley, of the School of Engineering, welcomed the group of visitors, and presented Prof. C. A. Ellis, president of the Section. John W. Wheeler, M. Am. Soc. C.E., a trustee of the University, spoke briefly, comparing the present program and activities of the University with things as they were when he, as a member of the 1916 class, attended the first session of the summer school of surveying in Clark County.

M. R. Keefe, chief engineer of the State Highway Commission and Contact Member for the Purdue University Student Chapter, addressed the students and stressed the close relationship that should exist between the practicing members of the profession and the students preparing to enter it. Pointing out that the common meeting ground in fostering this relationship was the technical and professional society, Mr. Keefe urged all the student members to be active in the Student Chapter and to affiliate with the Society after graduation.

R. B. Stewart, comptroller of the University, and A. A. Potter, dean of engineering, spoke briefly, the latter discussing the duty of the engineer to the community.

The members of the Section were urged to contact the Juniors, especially those within their own organizations, and interest them in the writing of papers for the Section award, which is to be made this year for the first time.

Following the meeting, games and contests were participated in by the members and their families. In addition to the staff members at the camp, 28 members of the Section and two guests were present. The committee on program, of which L. E. Martin is chairman, worked with Prof. G. E. Lommel, director of Ross Camp, in arranging the details for the meeting.

Papers Filed in Library

ATTENTION is called to the following papers, which have been contributed to the Society for filing with the Engineering Societies Library, 29 West 39th Street, New York, N.Y. Charges for photostating will be quoted by the latter organization on request.

SUGGESTION FOR INLAND NAVY YARD

BAYLES, G. H., M. Am. Soc. C.E., "A Suggestion for Improving the Mississippi River and Providing for an Inland Navy Yard" (9 typewritten pages—about 2,500 words). The author proposes straightening and deepening the Mississippi River, and lining the channel with reinforced concrete, to permit the establishment of an inland navy yard at Cairo, Ill., which "would be safe from enemy attack, even in planes." Peace-time advantages would be the elimination of the flood menace on the lower Mississippi, and the establishment of a seaport in the heart of the country. He estimates the cost of the improvement at $3,000,000,000.

STRESSES UNDER A FOUNDATION

WEISKOPF, WALTER H., M. Am. Soc. C.E., "An Elastic Theory for Stresses Under a Foundation" (16 typewritten pages of text and equations—about 4,000 words—plus 7 pages of drawings). "The analysis of stresses under a foundation, as developed by the classical mathematicians," says the synopsis of this paper, "assumes an elastic isotropic substance of indefinite extent. . . . The analysis here presented recognizes at the start that certain relations true for elastic isotropic substances do not hold for soils, and avoids the introduction of these into the fundamental differential equations . . . . Certain simplifications in the differential equations are made in order to effect a mathematical solution. This solution is based on cartesian coordinates in three dimensions and therefore is most easily applied to bearing areas rectangular in shape. The results of the theory are compared with known experimental measurements."

Student Reporters at Society Meeting

A UNIQUE news-gathering method was put into operation at the Spring Meeting of the Society in Jacksonville last April, when six seniors from the College of Journalism at the University of Florida were assigned to cover the general and technical sessions of the Society, the American Shore and Beach Preservation Association, and the Florida Engineering Society. Publicity headquarters was very glad to have such able assistance and found that the stories turned in by these young reporters were of professional grade.

The names of these journalistic aspirants are Victor Bogachoff, Armand Bonnette, Don Brown, Rod Elkind, Kenneth Horton, and Jack Long, Jr. Mr. Long is the son of J. A. Long, Assoc. M. Am. Soc. C.E., president of the Florida Section.

The success of this plan warrants its consideration by other local committees in charge of Section, regional, or Society meetings. All the work was coordinated at the publicity headquarters sponsored jointly by the Jacksonville Engineering Professions Club, the Florida Engineering Society, and the Florida Section, Am. Soc. C.E. Martin Fabian was publicity director.

Freeman Scholarship Is Awarded

UNDER the terms of the Freeman Traveling Scholarship, another young engineer will soon sail for a year's study in the hydraulic laboratories of Europe. The successful candidate in this year's competition is Lt. Douglas C. Davis, assistant director of the U. S. Waterways Experiment Station at Vicksburg, Miss.

Lieutenant Davis was born in Tacoma, Wash., on May 24, 1910. Most of his elementary education was obtained in San Francisco. After a year of junior college in San Mateo, Calif., he enlisted in the Regular Army (30th Infantry, Presidio of San Francisco) for the purpose of obtaining appointment to the U. S. Military Academy at West Point. He was graduated from West Point in 1933, commissioned a second lieutenant in the Corps of Engineers, and reported at his first post for duty with the 6th Engineers in Fort Lewis, Wash. After two years of troop duty, he proceeded in turn to the Engineer School at Fort Belvoir, Va., and to the Massachusetts Institute of Technology in Boston for a postgraduate course in civil engineering. Thence, he was assigned for his first river and harbor detail as assistant to the director of the U. S. Waterways Experiment Station. In the absence of the director, Lt. Paul W. Thompson, he is now acting director.

As stated in his application, Lieutenant Davis's tentative objective is an investigation of field verification of open-channel models. He plans to collect model data and corresponding data on the actual behavior of the prototypes, and correlate the information.

Lieutenant Davis is the eleventh to receive the scholarship from the Society since 1924, when the fund that makes it possible was set up by the late John R. Freeman, Past-President and Honorary Member of the Society. The recipient of the 1936 award, John Hedberg, is now assistant professor of civil engineering at Stanford University. The award was not made in 1937.

Badges with Histories

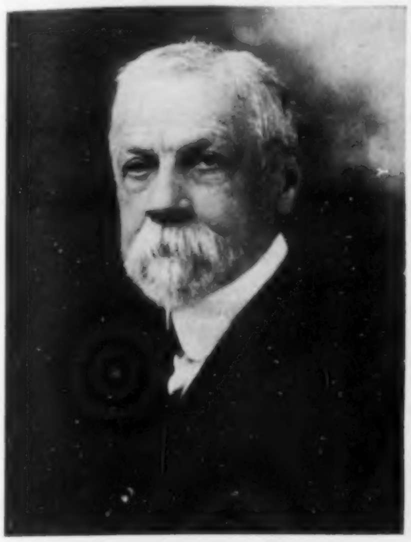
LAST MONTH'S pin-that-came-back story has stimulated others—from Ross C. Durst and T. Kennard Thomson. Mr. Durst writes that some years ago he sent a suit to the cleaners without removing the badge. "Diligent inquiry convinced me that I had been 'taken to the cleaners,'" he says, "so I bought a new pin. About five years later a stranger called and informed me he had my pin. It had been found by a Boy Scout in a vacant-lot ball diamond. I had never been in that part of town in my life."

Badge 229J was issued to Mr. Thomson in 1888. He writes: "It was lost in Washington, D.C., one September about 25 years ago; picked up in the park by a younger member of the Society, and handed back to me at the next Annual Meeting in New York." Mr. Thomson still has the pin, now fifty years old. The "229J," as he points out, means that he was the 229th to be elected a Junior in the Society. Similarly, a number followed by "A" is the order of associate membership, and a number without a letter is the order of full membership.

Early Presidents of the Society

XXIX. Desmond FitzGerald, 1846–1926
President of the Society, 1899

Like many another engineer of his day, Desmond FitzGerald had no formal training in engineering. In fact, his schooling ended with graduation from Phillips Academy, and at that time he apparently still cherished some desire to become a sculptor. He shortly settled on the profession of engineering, however, and within a few years he had already begun to achieve prominence in that field.



Desmond FitzGerald
Twenty-Ninth President of the Society

Desmond FitzGerald was born in 1846 in the Bahama Islands. His father, an officer in the British Army, hailed from Ireland, while his mother came of Colonial stock and was a direct descendant of Roger Williams. The FitzGerald family removed to Providence in 1848 and maintained its home there for many years. In fact, as late as 1923 FitzGerald still owned several lots of land in that city—part of a tract which originally had been granted to Roger Williams and which had never been out of the family.

Young FitzGerald received his early education in the public schools of Providence, and when 11 years old went to Paris to study art. His cousins, with whom he resided in Paris, were people of wealth and influence and this, in connection with the opportunities which Paris afforded, may have had great influence on his taste for art and his love of it.

On his return to the United States he entered Phillips Academy at Andover, N. H., from which he was graduated in 1864. While still under age, he became deputy secretary of the state of Rhode Island and in 1866 was private secretary to General Burnside, then governor of the state. During this period he found time to engage as "student" in the engineering office of Cushing and Dewitt, the leading engineering office in Providence.

Smooth Stakes Attract Attention

When twenty-one, he started West to seek his fortune as axeman on the Indiana and Vincennes Railroad. An anonymous biographer in *Engineering News-Record* (September 30, 1926) quotes his as follows on his experiences on that work: "My motto was to do anything I had to do as well as it was possible to do it. I found poor stakes in use and set myself to make better ones—square and well-smoothed for the cut-and-fill figures, which I put on boldly and legibly. When a superior came over the survey line he asked who made the stakes and declared them to be the finest he ever saw." The attention he thus attracted, plus his mastery of Henck's Field Book, led to a rapid advancement. "I was promoted to be rear, then front chainman, rodman, and transitman, the latter at $75 a month. I saved most of my wages and bought C.B. & Q. stock."

Three years later FitzGerald was assistant chief engineer of the Cairo and Vincennes Railway, and in 1871 he returned to Boston to become chief engineer of the Boston and Albany Railroad. This position, which was none too well paid, he accepted in preference to a government position on construction in Boston Harbor, and in preference to a partnership in an architect's office.

His work on this railroad brought him in contact with Joseph P. Davis, M. Am. Soc. C.E., and this in turn led to his appointment as superintendent of the Western Division of the Boston Water Works, which included the Brookline and Chestnut Hill Reservoirs, Lake Cochituate, and the connecting aqueduct, embracing substantially all the sources of supply of the city. This position he held from 1873 until 1898.

While in office as superintendent, he was the active factor in overcoming a reluctance on the part of the city authorities (other than the City Attorney, who supported him) in bringing suit to secure elimination of pollution of the water supply, partly by manufacturing wastes and partly by municipal sewage. This was the case of Pegan Brook in Natick, Mass. Upon FitzGerald fell the task of securing evidence and tracing actual cases of pollution to their source. "The assistant corporation counsel," said FitzGerald in substance, according to the *News-Record* biographer, "was a stickler for evidence and not satisfied with proof that a sewer led from the hotel to the brook. So I had balls painted and numbered, put them in the hotel water closets and recovered them in the sewer and in the brook." This case, perhaps the first of its kind in the United States, resulted in a final decision by the supreme court of the state in favor of the city of Boston, after seven years of litigation. It was decided on the ground that the act authorizing Boston to take water granted to the city the right to the water in its then state of purity, whereas the hotel had subsequently turned water-closet wastes into the brook.

A Pioneer in Study of Bacteriology of Water

FitzGerald was the first to establish a biological laboratory in connection with water supply and to study especially the bacteriology of water. The little wooden building near the Chestnut Hill Reservoir was for many years after 1891 the only biological laboratory operated in this country in connection with a water works system, and was the source of many important contributions to sanitary engineering. Especial mention may be made of the pioneer studies conducted there of the color in water and the methods of reducing it. As a result of these studies, FitzGerald was led to adopt the practice of draining the swamp lands within the watershed contributing to the water supply, stripping the top soil and humus from the reservoir beds, and taking advantage of sunlight for bleaching the stored waters.

In cooperation with William E. Foss he developed an improved type of colorimeter which made use of the "platinum standard" devised shortly before by the late Allen Hazen, M. Am. Soc. C.E. It permitted a more rapid and accurate determination of water color than had theretofore been possible. (This colorimeter is described in the *Journal of the Franklin Institute*, December 1894.)

Other routine research at the Chestnut Hill laboratory included weekly chemical analyses and determinations of the organisms in the water from the various reservoirs of the Boston system, and this information was used to determine from which particular reservoir the most satisfactory supply could be drawn at any particular time.

FitzGerald was always willing to take the pains necessary to put the results of his investigations at the disposal of the profession. Most of his papers were published in the Transactions of the Society. Among these was the classic treatise on "Evaporation" which received the Norman Medal in 1887—the basic equation developed in that paper was closely confirmed by later laboratory experiments and is still used in evaporation studies. A later paper, "Rainfall, Flow of Streams, and Storage," also received the Norman Medal (1893). Only two other men—John R. Freeman, Past-President and Hon. M. Am. Soc. C.E., and C. C. Schneider, M. Am. Soc. C.E.—have been twice winners of this prize.

When the old system of supply for Boston was absorbed by the newly created Metropolitan Water Board in 1898, FitzGerald was retained as engineer of the Sudbury Department. During his employment with this board it was understood and provided that he was free to act as consulting engineer for other municipalities, and he engaged actively in such work. Of particular interest was his employment in 1899 as consulting engineer for the Chicago Drainage Canal.

This work involved the review of the designs of that great project, and of the structures in so far as they had been completed. The special commissions directing the investigation had been authorized to pay the magnificent sum of $10 per day for "a prominent and skilled engineer of national reputation" to take in hand the tasks required. After a few unsuccessful attempts, the com-

missioners appealed to the general assembly of Illinois to increase the allowance for engineering services; and the assembly promptly complied. It is said that the salary actually paid to FitzGerald following this act was the largest that had ever been paid to any civil engineer up to that time. Other projects in which FitzGerald had a part were the investigation of the Lydecker Tunnel, then under construction for the water supply of Washington, D.C.; the important "Hetch Hetchy" case of San Francisco; and the water supply and sewerage of Manila.

For the commonwealth of Massachusetts, FitzGerald served for several years as chairman of the Topographical Survey Commission under whose direction the New York–Massachusetts state line was rerun in 1897. The work was made difficult by the fact that important monuments had been forcibly removed and shifted far from their proper positions. It was ultimately accomplished, however, to the satisfaction of both New York and Massachusetts, and thus an end was put to the intermittent boundary disputes that had begun more than 200 years before, and that on at least one occasion in Colonial times had led to the organization of militia companies and to various armed encounters.

FitzGerald set a high standard of public spirited citizenship. In the town of Brookline, where he made his home, he was chairman of the Park Commission from 1897 until his health made it advisable for him to retire in 1926. He was also president of the Civic Society of Brookline and was one of the trustees of the public library from 1887 to 1926.

When the town meeting became so large that a smaller representative body was elected, he was chosen as a member, and had much influence in its meetings. He was unusually effective in securing what he felt was needed in connection with his official interests even when considerable opposition was manifested. During the World War he drilled with the local unit, lectured on patriotism, and was otherwise active for the cause.

An invitation to become a Lowell Institute lecturer in Boston is a recognized honor, and FitzGerald once delivered four lectures there in a course of 12 on engineering. (Lowell Institute was organized upon the bequest of $250,000 left by John Lowell, 1799–1836, "for the maintenance and support of public lectures to be delivered in Boston, upon philosophy, natural history, the arts and sciences, or any of them, as the trustees shall from time to time deem expedient for the promotion of the moral, and intellectual and physical instruction and education of the citizens of Boston." The first lecture was delivered in 1839, by Edward Everett.)

CONTRIBUTIONS TO ART

As previously mentioned, FitzGerald was a lover of art. His circumstances, as well as his taste and temperament, qualified him to become a patron of art as well as a connoisseur and critic, and in these combined capacities he was a leading figure around Boston. Dodge MacKnight, a brilliant water color artist, most highly regarded in Boston, received his first substantial recognition from FitzGerald, who not only led in public encouragement of the artist but also acquired and owned three-score of his pictures, covering various stages of his development. In addition he was the author of a monograph on Dodge MacKnight, privately printed and circulated. He was among the first in this country to appreciate the early impressionist, Claude Monet, and others who followed in the same school. He was on terms of personal friendship with MacKnight and Monet, and also with John Singer Sargent.

To accommodate his paintings, he built an art gallery, 27 by 61 ft, adjoining his residence, which later proved all too small for his collection. This gallery was open to the public.

He was also a trustee of the Boston Museum of Fine Arts. Following his death, the trustees adopted the minute of which a part follows:

"By the death of Desmond FitzGerald the Museum lost a friend who was deeply interested in its work. In 1916 he was appointed a member of the Board of Trustees by the Institute of Technology, a position which he held up to the time of his death. He was affiliated with a great variety of institutions and commissions, and was more or less associated with all the societies that had to do with art in Boston. He had great sympathy with young painters, and he bought their work and did all that he could in other ways to help and encourage them. He was an extensive traveler and traveled intelligently, for he cared for the things he saw from the point of view of an artist as well as from that of an engineer. To him art was always a joyful inspiration—an inspiration that added greatly to his gaiety and happiness throughout his long and useful life."

FitzGerald was not without ability as an amateur artist, and his crayon portraits of members of his family were to be seen on his walls. He traveled much, and his artistic taste and his skill as a photographer resulted in several interesting illustrated lectures, mainly if not altogether to his friends, personal and professional.

His professional activities were constant. He was active in the revival of the Boston Society of Civil Engineers in 1873 and 1874, and was among the earliest of the younger men to be elected president. Later he was elected an honorary member. For many years he made a liberal annual contribution to that society's permanent fund, and remembered it in his will. He also, in 1910, established a fund for the award of a bronze medal annually to the author of the best paper of the year.

He served a term as president of the New England Water Works Association, and was an honorary member of the American Water Works Association and a member of the American Institute of Consulting Engineers. As President, Honorary Member, and twice Norman Medallist of the Society, he attained a unique distinction.

"He was much more than a mere technical engineer," wrote the authors of his memoir in TRANSACTIONS (1928). "He was a broadly cultivated man with many points of contact outside of engineering. He was thoroughly human, not enclosed in a rigid shell of mathematics or technical detail. Slight in stature, he had an abundance of physical and mental energy, and accomplished much in the various lines of his activities, and his genial presence supplemented his other fine qualities. As a public citizen, few gave more for the betterment of the community. In his love for art and its encouragement, and in his church work, he qualified in the finer things of life, artistic and spiritual."

FitzGerald was married in 1870 to Elizabeth E. C. Salisbury, and was survived by two daughters and two sons.

The Sacramento Section Has Its 750th Meeting

FOR A NUMBER of years the members of the Sacramento Section have enjoyed weekly luncheons, and the regular gathering on June 28 marked the 750th meeting of the Section. The program scheduled for this occasion attests the wide interests of the members of the Section, the subject of discussion being the activities of the state bar and their relationship to the public. This was presented by Gilford G. Rowland, president of the California State Bar.

In fact, uniformly fine programs guarantee the enthusiasm of the membership, and the luncheon meetings are well attended. Three additional gatherings of this sort also took place in June—on the 7th, 14th, and 21st, respectively. At the first of these sessions B. M. Durland, of the General Railway Signal Company, spoke on the subject, "Installation of Signal and Interlocking Equipment on the Bay Bridge," before an audience of 52. The speaker at the meeting on the 14th was Edward A. Fairbairn, county engineer of Sacramento County, who gave an illustrated talk on first aid. And on the 21st George E. Goodall, senior engineer of the U. S. Engineer Office, discussed "Arch Dams for Debris Control."

A special feature sponsored by the Section in June was a trip to the new U. S. Army air depot at Ben Ali, just north of Sacramento. On this occasion Col. H. E. Pitz, Constructing Quartermaster, and others on his staff, acted as hosts to the members and their families. The trip was arranged by A. J. A. Meehan and R. W. Hutchinson, of the entertainment committee.

Indiana Section Establishes Unique Junior Award

AN INNOVATION in Local Section activities is the prize competition recently established by the Indiana Section for its Juniors. Similar in its terms to the Collingwood Prize for Juniors, the purpose of this competition is to stimulate the preparation of papers describing the design, construction, economics, historical development, or other features of an engineering work with which the writer has been directly connected. Accuracy of language and excellence of style are also to be factors in the award.

The first prize will consist of a prize certificate and a cash award of $25. If the quality or number of papers submitted justify such action, second, and possibly, third prize certificates and cash awards may be given, the latter having values of $15 and $10, respectively.

The competition is restricted to Juniors of the Indiana Section, and papers previously published will not be eligible for the prizes. Juniors planning to enter the competition should notify the secretary of the Section of their intention and should keep in mind the fact that the deadline is January 1, 1939.

Memoirs of Deceased Members Available

During the year memoirs of deceased members have been prepared for publication in Transactions. This work is done progressively so that individual preprints of these memoirs can be distributed to the members of the family and to intimate friends on request. The following list supplements the short list published in the January 1938 issue of Civil Engineering.

Charles Rollin Allen	1872–1937
William Bullard Allen	1863–1938
Russell Averill Anderson	1896–1937
William Delano Armstrong	1872–1937
Richard I. Downing Ashbridge	1861–1936
Albert Worthington Atwater	1885–1937
John Leland Becton	1885–1938
Charles Robert Bettes	1863–1937
Edwin Brightman	1911–1937
Frank David Chase	1878–1937
John Carroll Chase	1849–1936
Clarke Peleg Collins	1868–1937
Elbridge Robbins Conant	1865–1937
Verne Louis Conrad	1879–1937
Hugh Lincoln Cooper	1865–1937
William Herbert Cushman	1869–1937
Harry Jocelyn Dignum	1878–1936
Joseph Oscar Eckersley	1873–1930
Ross Elroy Hamilton	1879–1937
William Johnson Harahan	1867–1937
Foster Warren Harvey	1899–1937
Lewis Muhlenberg Haupt	1844–1937
Wyatt Swift Hawkins	1876–1937
Harry Monmouth Herbert	1857–1937
Nicholas Snowden Hill, Jr.	1869–1936
Robert Bruce Hoadley, Jr.	1879–1937
Richard Frederick Hoffmark	1882–1937
Jacob Duncan Jaques	1878–1936
Christian Peter Jensen	1873–1937
Francis Howe Kendall	1869–1937
Frank Perry Larmon	1878–1937
Attilio Felix Lipari	1890–1938
Frank Alexander McInnes	1856–1937
James Daniel Mickey	1913–1937
Daniel Edward Moran	1864–1937
Joseph S. Morrison	1874–1937
Jay Johnson Morrow	1870–1937
Sven Albert Norling	1894–1937
Thomas Sarsfield O'Connell	1888–1937
Robert Vance Orbison	1882–1937
Raymond Stanton Patton	1882–1937
Carroll Paul	1882–1937
Arthur Lowrie Reeder	1879–1937
Theron Monroe Ripley	1868–1936
Beale Melancthon Schmucker	1888–1937
William Lee Selmer	1885–1937
Eugene Raymond Smith	1858–1938
Christopher Henry Snyder	1866–1937
Lawrence King Snyder	1906–1937
Ambrose Swasey	1846–1937
Arthur Carling Toner	1881–1937
Philip Scott Tyre	1881–1937
George Reed Wadsworth	1875–1937
Henry Radclyffe St. Arvans Walters	1875–1937
James Goold Warren	1858–1937
Samuel C. Weiskopf	1860–1936
Winter Lincoln Wilson	1866–1937
Warren Withee	1893–1938
Walter McIlhaney Wolfe	1887–1937
Robert Joseph Henderson Worcester	1882–1937
David LeRoy Yarnell	1886–1937

News of Local Sections

Scheduled Meetings

Sacramento Section—Regular luncheon meetings at the Elks Club every Tuesday, at 12:10 p.m.

San Francisco Section—Dinner meeting at the Engineers Club on August 16, at 5:30 p.m.

Texas Section—Luncheon meeting of the Dallas Branch at the Dallas Athletic Club on August 1, at 12:15 p.m.; luncheon meeting of the Fort Worth Branch at the Blackstone Hotel on August 13, at 12 m.

Recent Activities

Central Ohio Section

On June 16 the Central Ohio Section held its last meeting before the summer recess. This gathering, which took the form of a luncheon, was attended by 25. The speaker was F. W. Davis, chairman of the department of photography at Ohio State University, who discussed the use of the motion picture as a tool in research. Professor Davis illustrated his talk with a number of motion pictures, showing just how such pictures can aid in engineering research. The Section announces the award of two student prizes. The Robert H. Simpson award of $25 in cash, given annually to the author of the best thesis submitted for the degree of bachelor of civil engineering at Ohio State University, is divided this year between Alfred Grabill Cochran and Edward Luther Miller, both members of the 1937 graduating class. The Section award of Junior membership in the Society goes to Charles L. Guard, 1938 graduate of Ohio State University with the highest scholastic record.

Los Angeles Section

There were 130 members and guests present at the June dinner meeting of the Los Angeles Section, which was held at the University Club on the 8th. Following dinner Clarence J. Derrick gave a humorous talk on the subject, "Living an Engineer's Life." The technical program consisted of two papers dealing with construction work on the Imperial Dam on the Colorado River. These were presented by Ralph M. Conner, construction superintendent on the project, and Don M. Forester, an engineer in the Yuma (Ariz.) office of the U. S. Bureau of Reclamation. The former described the design and construction of the Ambursen-type diversion dam, while Mr. Forester discussed the design, construction, and proposed operation of the All-American Canal de-silting works at the Imperial Dam.

Preceding the dinner, the Junior Forum of the Section met at the University Club. This group was addressed by E. A. Colman, who gave an illustrated lecture on the San Dimas experimental forest.

Louisiana Section

On June 13 a joint meeting of the Louisiana Section and the Louisiana Engineering Society took place at New Orleans, with A. J. Negrotto, vice-president of the Section, in the chair. There were over 200 present on this occasion to hear an interesting talk on past and proposed public works improvements in the city of New Orleans. This was given by Hampton Reynolds, chairman of the New Orleans Development and Planning Commission. The Section announces that its awards of Junior membership in the Society to outstanding senior civil engineering students go to Jack S. Burk, of Tulane University, and Ernst A. Bullington, of Louisiana State University.

Oklahoma Section

A report from the Oklahoma Section indicates that several interesting meetings have been enjoyed during the past few months. A two-day joint session with the Oklahoma Society of Professional Engineers was enjoyed on January 21 and 22. The Oklahoma Section had charge of the program on the first day, when the following speakers were heard: W. J. Armstrong, chief conservation engineer for the Oklahoma State Conservation Commission; Paul Reed, associate editor of the *Oil and Gas Journal:* and W. T. Born, of the Geophysical Research Corporation. In addition, three

members of the Oklahoma State Department of Public Safety described various phases of the department's work, and two sound motion pictures were shown. One of these, depicting the construction of the Golden Gate Bridge, was available through the courtesy of the American Institute of Steel Construction; and the other, entitled "City of Tomorrow," was prepared by Dr. Miller McClintock, director for State Traffic Research at Harvard University, and the noted designer, Norman Bel-Geddes. On the 22d the following speakers were heard: J. D. Durkee, of the Phillips Petroleum Company; W. R. Holway, consulting engineer; and A. B. Adams, of the staff of the University of Oklahoma. The total registration was approximately 400. On March 26 there was a joint meeting with the Oklahoma Agricultural and Mechanical College Student Chapter at Stillwater. On this occasion G. H. James, a contractor, showed motion pictures of the Purcell-Lexington Highway Bridge. On May 17 there was another Student Chapter meeting—this time with the University of Oklahoma. The speakers were Victor H. Cochrane, consulting engineer of Tulsa, and Professor Willowby, of the university staff.

Panama Section

The list of 29 present at the June 6th meeting of the Panama Section included a number of technical students from the Balboa Junior College. The principal speaker was I. F. McIlhenny, who gave a general description of Madden Dam and the water-control apparatus as well as of the tests run on the model and on the prototype. An enthusiastic discussion followed. The final speaker was T. B. Monniche, of Boquete, Panama. Mr. Monniche who held various positions of responsibility on the construction of the Panama Canal made some general remarks of interest.

Philadelphia Section

A golf tournament was the feature of the annual meeting of the Philadelphia Section, which was held at the Sandy Run Country Club near Philadelphia on the afternoon and evening of June 15th. Following dinner and the tournament, first prize for golf went to Ivan M. Glace, and consolation prizes to those less fortunate. The report of the tellers announcing the new Section officers was then read. These are William E. A. Doherty, president; Scott B. Lilly and Harry M. Freeburn, vice-presidents; and Charles A. Howland, secretary-treasurer. During a general discussion of Section activities, many valuable suggestions as to ways in which the Section can be of service, not only to its members but to the community as well, were made. President Chorlton expressed his appreciation for the support and cooperation given him during his term as president, and then turned the meeting over to Mr. Doherty, who thanked the Section for the honor given him and pledged his best efforts for a successful year. The attendance was 38.

Pittsburgh Section

On May 12 the annual business meeting of the Pittsburgh Section was held at the William Penn Hotel. Following the transaction of business and the election of officers (reported in the July issue), the Section prizes of Junior membership in the Society were awarded senior-class civil engineering students with the highest scholastic ranking. These students are Daniel R. Beech, of the Carnegie Institute of Technology, and W. S. Davis, of the University of Pittsburgh. On behalf of the Section, R. P. Forsberg, retiring president, then presented Nathan Schein with a silver candelabra in recognition and appreciation of his twenty years of service as secretary-treasurer of the Section. The meeting was then turned over to the Juniors, who had arranged a program of short talks on the "Problems of the Young Engineer." Those who participated in this symposium were J. W. McKnight, A. K. Spalding, C. P. Capp, and William A. Robinson, all Juniors. A buffet supper and social hour concluded the evening.

Portland (Ore.) Section

Approximately 85 members and guests of the Portland (Ore.) Section and the woman's auxiliary met at Bonneville, Ore., on the afternoon of June 18 to inspect the Bonneville Navigation—Power Project being constructed by the U. S. Corps of Engineers on the Columbia River. The district engineer and members of his organization guided the group and operated the major pieces of equipment for their benefit. After the inspection tour and dinner, a lantern slide lecture on Mexico was shown by Mr. and Mrs. O. E. Stanley, who had taken the pictures on a recent trip. A game of bridge concluded the evening.

Rochester Section

A joint meeting of the Rochester Section of the Society and the Rochester Engineering Society took place at the Sagamore Hotel on June 9, with 295 present. The feature of the occasion was a motion picture entitled "Bridging a Century," which gave a brief résumé of the history of suspension bridges, concluding with the construction of the Golden Gate Bridge. The manufacture and spinning of the cables were covered in detail.

San Diego Section

A meeting of the San Diego Section took place on June 23, with 19 present. Following the regular business session, an interesting talk was given by Raymond A. Hill, Director of the Society. Mr. Hill described the Salt River Project, stressing particularly the corrective measures necessary to bring the spillways up to capacity.

San Francisco Section

During June the San Francisco Section sponsored some interesting activities. On the 1st there was a joint session with the Building Industry Conference Board, at which the topic of discussion was the FHA housing plan. The regular meeting of the Section took place on June 21, with an attendance of 152. The program on this occasion consisted of a talk by F. T. Letchfield, consulting engineer and vice-president of the Wells Fargo Bank, San Francisco, who discussed the topic, "Backstage in Europe's Industries."

The Junior Forum of the Section held its last meeting of the season on May 17. The list of those present included 28 members of the Forum and A. V. Saph, consulting structural engineer of San Francisco, who represented the Section. "Should All Construction Projects Be Economically Sound?" was the topic of discussion, which aroused a great deal of spirited comment. The principal speaker of the evening was W. T. Corum, of the U. S. Forest Service, who discussed the floods of early March in southern California. His talk was illustrated by lantern slides. During the business discussion plans were made for an outing, to take the place of one of the regularly scheduled meetings, and matters were left in the hands of a committee consisting of Charles Dodge, W. C. Hamilton, and N. J. Kendall.

South Carolina Section

A two-day session of the South Carolina Section of the Society and the South Carolina Society of Engineers convened at Charleston, S.C., on June 10 and 11, with 22 present. Although this meeting was social rather than technical in nature, there was an interesting talk by Gen. C. P. Summerall, retired Army officer and president of The Citadel. General Summerall's topic was "The Engineer During War." During the business session a committee on the registration of professional engineers was appointed. This committee, which consists of B. P. Rice, D. T. Duncan, and R. B. Cureton, is to cooperate with registration committees from the South Carolina Society of Engineers and the South Carolina Board of Engineering Examiners to study the present registration laws in South Carolina and, if necessary, to bring the model law before the legislature.

Spokane Section

Announcement of the award of the Spokane Section prizes of Junior membership in the Society was the feature of the June 10th meeting of the Spokane Section. These prizes go to Chalmers Thornber, of Montana State College, for his paper on "Resurfacing the Red Lodge—Cooks City Highway"; and to Gomer Condit, of the University of Idaho, for his paper on "Soil Stabilization with Asphalt Emulsions." During the business session C. L. Barker was chosen to represent the Section at the Salt Lake City Meeting. The attendance was 13.

Tacoma Section

The June meeting of the Tacoma Section was held at the Lakewood Community Center on the 14th, with 57 present. A brief résumé of plans for the forthcoming Annual Convention of the Society at Salt Lake City was presented by Ross K. Tiffany, Director of the Society, and B. P. Thomas discussed matters of local interest. The technical program consisted of a symposium on bridges in Washington. This was presented by Clark H. Eldridge, A. M. Buell, George Stevens, and Ralph W. Finke, who illustrated their remarks with charts, slides, and tables. All four are connected with the Washington State Highway Department.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for September

Among the papers scheduled for the September issue of Civil Engineering is one by Raymond F. Dawson, M. Am. Soc. C.E., on settlement studies of the San Jacinto Monument, in Texas. The base of this monument—a monolithic concrete slab 124 ft square—provides an ideal opportunity to observe the action of an isolated footing on a deep bed of clay. An elaborate system of observation points was established in the base, and settlement readings are being taken at regular intervals. The results show good correlation with those predicted from laboratory tests at the time of construction.

In another paper, John R. Dawson, Jun. Am. Soc. C.E., describes the model testing of seaplane floats and hulls that is carried on in the testing tank maintained by the National Advisory Committee for Aeronautics at Langley Field, Va. In this half-mile-long tank, models

Model Test of a Seaplane Hull

may be towed at speeds as great as 80 miles per hr to assist in the solution of the all-important "take-off" problem.

Looking back to the 1880's, Robert Ridgway, Past-President and Hon. M. Am. Soc. C.E., recalls his life as a surveyor on the frontier in the building of the Northern Pacific Railroad, and his experiences on the construction of the New Croton Aqueduct in New York. The title of his story is "My Days of Apprenticeship."

On the schedule also are several papers from the program of the Annual Convention, on surveying and mapping, air transportation, sewage disposal, and irrigation.

Lake Ben Morrow

By action of the city council of Portland, Ore., the reservoir created by Bull Run Dam has been officially named Lake Ben Morrow, in honor of Ben S. Morrow, Assoc. M. Am. Soc. C.E. Mr. Morrow has been with the Water Bureau of the City of Portland for 29 years, serving successively as assistant engineer, principal assistant engineer, and chief engineer and general manager, the positions he now holds. The Bull Run storage project was built under his direction in 1928–1929 .

Christening ceremonies for the lake were held on June 12 under the auspices of the Geological Society of the Oregon Country, and a special invitation was extended members of the Portland Section of the American Society of Civil Engineers to attend. An automobile caravan left Portland in the morning, making stops at points of interest along the route. After lunch at the headworks, the party continued to Bull Run Dam, where the ceremony took place.

Interesting features of Portland's water supply system, including the Bull Run storage project, were described by Mr. Morrow in an article in the October 1936 issue of Civil Engineering.

Steel Construction Institute Announces Bridge Awards

Awards for the four most beautiful steel bridges constructed during 1937 were announced by the American Institute of Steel Construction at a dinner held on June 23, 1938. First place in Class A (bridges costing $1,000,000 and over) went to the Golden Gate Bridge across the Golden Gate at San Francisco. The consulting engineers on this project were O. H. Ammann, L. S. Moisseiff, and Charles Derleth, Jr., all Members of the Society; and the late Joseph B. Strauss was chief engineer.

First place in Class B (bridges costing between $250,000 and $1,000,000) went to the Little Hell Gate low-level bridge between Randalls Island and Wards Island, New York City. Mr. Ammann was chief engineer; Allston Dana, M. Am. Soc. C.E., engineer of design; and Aymar Embury II, M. Am. Soc. C.E., architect. In the same class, the Northern Boulevard Bridge over Intramural Drive, Flushing Meadow Park, New York City, was awarded honorable mention. The engineering firm on this structure was Madigan-Hyland.

In Class C (bridges costing less than $250,000) first place went to the Chesterfield-Brattleboro Bridge over the Connecticut River on Route 9. The engineers were John W. Childs, M. Am. Soc. C.E., bridge engineer, and Harold E. Langley, designing engineer.

First place for movable bridges went to the Marine Parkway Bridge over Rockaway Inlet, New York City. Madigan-Hyland were consulting and supervising engineers on the entire project; Waddell and Hardesty, consulting engineers on the design of lift and flanking spans; and Robinson and Steinman, consulting engineers on the design of deck spans. Again Mr. Embury was the architect. Honorable mention for movable bridges went to the Shark River Bridge on Ocean Avenue, between Belmar and Avon, N.J. The engineers were Ash-Howard-Needles and Tammen, with Morris Goodkind, M. Am. Soc. C.E., acting as associate consultant.

The prize-winning structures will be decorated with stainless steel plaques designating them the most beautiful constructed during the year.

George H. Fenkell Honored on Retirement

In honor of George H. Fenkell, M. Am. Soc. C.E., retiring general manager and chief engineer of the Detroit Department of Water Supply, 286 men and women gathered at a dinner dance at the Detroit-Leland Hotel on July 14. The dinner was arranged by a committee of friends and associates in the Department of Water Supply. Those in attendance included present and former members of the Board of Water Commissioners, fellow workers, other local members of the Society, other engineering and social friends of the guest of honor, and their ladies. George S. Davison, Past-President and Hon. M. Am. Soc. C. E., and John N. Chester, M. Am. Soc. C.E., flew from Pittsburgh to Detroit for the occasion.

Douglas Dow, vice-president of the Detroit Board of Water Commissioners, acted as toastmaster. The speakers were Alex Dow, Hon. M. Am. Soc. C.E.; Malcolm W. Bingay, editorial director of the

George Harrison Fenkell

Detroit Free Press; Laurence G. Lenhardt, M. Am. Soc. C.E., new general manager of the Detroit Department of Water Supply; and Mr. Fenkell. Mr. Fenkell was presented with a bound volume containing signatures of many of the guests and former business associates. The banquet was followed by a floor show and dancing.

Forty-four years ago Mr. Fenkell, while still a student at the University of Michigan, was employed as a draftsman for the Detroit water works. In 1902 he became chief draftsman, and from 1913 to 1918 was commissioner of public works. He has served in his present capacity since 1918, and during those 20 years has been largely responsible for the transformation of a sadly inadequate water supply system into one of the most modern systems in the country.

Additional Honorary Degrees

SINCE the July issue of CIVIL ENGINEERING went to press, news of other members awarded honorary degrees during the past commencement season has been received at Society Headquarters. These are as follows:

C. FRANK ALLEN, M. Am. Soc. C.E., doctor of engineering, Northeastern University.

WILLIAM GERIG, M. Am. Soc. C.E., doctor of laws, University of Missouri.

PHILIP CURTIS NASH, M. Am. Soc. C.E., doctor of laws, Northeastern University.

A.I.E.E. Elects Officers

NEW OFFICERS of the American Institute of Electrical Engineers for the year beginning August 1, 1938, were introduced on June 21 at the Institute's annual summer convention held recently in Washington, D.C. Dr. John C. Parker, M. Am. Soc. C.E., vice-president of the Consolidated Edison Company of New York, is the incoming president.

As vice-presidents the Institute has elected Chester L. Dawes of Massachusetts, F. Malcolm Farmer, of New York, A. H. Lovell, of Michigan, and F. C. Bolton, of Texas. The new directors include Leland R. Mapes, of Illinois, Harold S. Osborn , of New York, and D. C. Prince, of Pennsylvania. W. I. Slichter was reelected national treasurer.

Brief Notes from Here and There

MEMBERS of the Oklahoma Section of the Society are cooperating in the convention of the Southwest Section of the American Water Works Association, to be held in Oklahoma City, October 17–19. Technical sessions, luncheons, and many social events are included in the program, which is expected to attract an attendance of about seven hundred.

THE TRANSACTIONS of the Third World Power Conference, which was held in Washington, D.C., in 1936, are soon to be published, and prospective purchasers are asked to place their orders at once so that the number of copies to be printed can be determined. A pamphlet giving the contents of each of the 10 volumes can be obtained from the American National Committee, Third World Power Conference, Interior Building, Washington, D.C.

* * * *

THOSE whose work involves a study of population trends will welcome the National Resources Committee's new 300-page book on *Problems of a Changing Population*. Two chapters of special interest are "The Trend of Population: Economic Aspects" and "Trends in Population Redistribution." Another recent National Resources Committee publication is *The Future of State Planning*, a 117-page book which treats such subjects as "Functions and Opportunities of State Planning Boards" and "The Position of the Planning Board in the Governmental Structure." Among the members of the "State Planning Review Group" which prepared this report are two members of the Society—Russell V. Black and Robert H. Randall. The two publications are for sale by the Superintendent of Documents, Washington, D.C., at 75 and 25 cents, respectively.

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"HIGHWAY Planning—a Symposium" is the title of an 84-page book just published by the Michigan State Highway Department, containing the papers presented at the 24th Michigan Highway Conference (February 1938). The material is drawn from the initial findings of that state's highway planning survey, and "focuses attention on some fundamental principles upon which sound highway administration should proceed with its future tasks." A copy has been deposited with the Engineering Societies Library in New York.

NEWS OF ENGINEERS

Personal Items About Society Members

ALVIN D. WILDER, consulting engineer of San Francisco, Calif., has been appointed executive director of the Housing Authority of the City and County of San Francisco.

C. P. TOMLINSON, of Hartford, Conn., is now a director and vice-president of the McColl-Frontenac Oil Company Ltd., with headquarters in Montreal, Canada.

JOHN L. HOGAN and BENJAMIN BERMAN announce the formation of the engineering and contracting firm, Hogan and Berman, to be located at 285 Madison Avenue, New York City. Until recently both were with the Triest Contracting Corporation of the same city—as chief engineer and deputy chief engineer, respectively.

RICHARD HATTRUP, an engineer for the Standard Oil Company of California, has been sent to Arabia to do some mapping and field engineering for the California Arabian Oil Company, a subsidiary of the Standard Oil Company of California.

CHARLES H. DODGE, of San Francisco, Calif., has been transferred to the Los Angeles office of the California Water Service Company.

JACOB DEKEMA is now employed as senior engineering aide in the bridge department of the State of California Division of Highways, with headquarters in Sacramento, Calif.

A. B. WIGLEY, formerly assistant engineer for the North Carolina State Board of Health, has accepted a position with Phipps and Bird, Inc., of Richmond, Va.

CLEVELAND R. HORNE, JR., is now employed as assistant civil engineering aide in the U. S. Waterways Experiment Station at Vicksburg, Miss.

SIDNEY S. GORMAN, senior bridge designing engineer for the State of California, has been appointed construction engineer of the California Commission for the Exposition, with headquarters at 666 Market Street, San Francisco.

C. W. MATTHEWS, of Albany, N.Y., is associated with L. SEGOE, consulting engineer and city planner, as resident planning engineer to the Municipal Planning Commission of Charleston, W.Va., in the preparation of a comprehensive plan for the city and its environs.

CECIL PRAY, previously junior highway engineer for the U. S. Bureau of Public Roads at Fort Worth, Tex., has become an instrumentman in the Texas State Highway Department, with headquarters at Throckmorton, Tex.

THOMAS M. PRICE is now general manager for Shea and Kaiser, contractors on the Delaware Aqueduct, Sec. 308. He is located at Bronxville, N.Y.

HERBERT D. VOGEL, captain, Corps of Engineers, U. S. Army, has been transferred from 3d Engineers, Schofield Barracks, Honolulu, Hawaii, to Fort Belvoir, Va., where he will serve as instructor in the Army Engineer School.

WILLIAM KENDRICK HATT, research professor and director of highway research at Purdue University, was awarded honorary membership in the American Society for Testing Materials at the 41st annual meeting, held in Atlantic City on June 28. Professor Hatt received the award for eminence in the field of engineering materials and for long and outstanding service in the American Society for Testing Materials, of which he has been a member since 1898.

A. V. RUGGLES, until recently assistant engineer designer for the New York Board of Water Suppiy, has been appointed assistant hydraulic engineer with the water bureau of the Public Service Commission, State of New York, with headquarters in New York City.

ROBERT A. WILSON, formerly assistant sanitary engineer for the Chicago Pump Company, of Chicago, Ill., has become connected with Wood, Walraven, and Tilly, civil engineers of Springfield, Ill.

PERRY B. HACKETT, who has been employed as a graduate assistant in the civil

engineering department of the Agricultural and Mechanical College of Texas, has accepted a position as assistant engineer with H. L. THACKWELL, consulting engineer of Longview, Tex.

LESLIE W. BOLLMAN recently received an appointment as an engineering assistant to the Board of Water Supply, City of New York, at Lackawack, N.Y.

ROBERT L. SACKETT, dean emeritus of engineering at Pennsylvania State College, has been awarded the eleventh Lamme Medal of the Society for the Promotion of Engineering Education. This award, which is given for outstanding achieve-

ROBERT L. SACKETT

ment in engineering education, was made at the society's annual convention dinner. Dean Sackett served as dean of the school of engineering at Pennsylvania State College from 1915 to 1937. Since his retirement in the latter year he has devoted himself largely to the work of the Engineering Council for Professional Development.

JAMES L. CHERRY has returned to H. A. Kuljian and Company, consulting engineers of Philadelphia, Pa., in his former capacity as an active member of the firm. Until recently he was assistant professor of architectural engineering at Pennsylvania State College.

CHARLES H. CLARAHAN, JR., is now assistant engineer for Strauss and Paine, Inc., consulting engineers of Chicago, Ill. He was previously designer for the Strauss Engineering Corporation of the same city.

WALTER E. KROENING, formerly chief designing engineer for the planning division of the Greendale Project at West Allis, Wis., has been made director of service and assistant community manager for the project. He will be in charge of the maintenance of all public, commercial, and residential buildings and public areas as well as the operation of various utilities.

CONRAD V. CARLSON has become connected with the Realty Syndicate of Lincoln, Nebr., in the capacity of air conditioning engineer. He was previously sales engineer for Clarence A. Flarshein, Inc., of Kansas City, Mo.

ARTHUR L. PAULS has been promoted from the position of project engineer on the construction of Pickwick Landing Dam for the Tennessee Valley Authority to that of chief construction engineer for the Authority, with duties relating to all the TVA dam construction projects.

SAMUEL F. RATHVON is now employed as a junior engineering draftsman by the U. S. Soil Conservation Service, with headquarters at Albuquerque, N.Mex. He was formerly an operator for the Nevada Consolidated Copper Corporation at Hurley, N.Mex.

E. Y. ALLEN has been appointed assistant chief engineer of the Reading Company, with offices in Philadelphia, Pa. Until recently he was special engineer for this company.

W. C. CHRISTOPHER, previously designing engineer for the Metropolitan Water District of Southern California, with headquarters in Los Angeles, Calif., has accepted the position of consulting engineer for the Comisión Nacional de Irrigación. He is located in Mexico City.

JOHN H. WILSON, until lately connected with the Walsh Construction Company, of Indianapolis, Ind., is now district representative for the R. G. Le Tourneau Company, Inc., of Peoria, Ill. His headquarters are in Columbus, Ohio.

A. M. ZABRISKIE has been appointed assistant chief engineer of the Central Railroad Company of New Jersey, with offices in Jersey City, N.J. He was formerly principal assistant engineer for this organization.

WILLIAM GERIG retired on April 1 after a number of years in the Corps of Engineers, U. S. Army. At the time of his retirement he was head engineer in the Office of the Chief of Engineers, Washington, D.C. He is now at his home in Arkadelphia, Ark.

C. E. GAMMAGE, formerly chief planning engineer for the Resettlement Administration at Birmingham, Ala., has accepted a position as associate engineer in the southeastern region of the Land Utilization Division of the U. S. Bureau of Agriculture Economics. His headquarters are in Atlanta, Ga.

CHARLES H. TOPPING, formerly designer for the Pan-Am. Refining Corporation at Texas City, Tex., has become sales representative for the Air Conditioning Company, of Houston, Tex.

DECEASED

HOMER GAGE BALCOM (M. '16) consulting engineer of New York City, died there on July 3, 1938, at the age of 68. In 1908, after several years with the American Bridge Company, he established his private consulting practice. An authority on both foundations and steel construction, Mr. Balcom designed the steel work for many notable buildings in the United States and Europe, including the Empire State and Chrysler buildings in New York City. During the war he had charge of engineering on fabricated steel ships built for the government at the Hog Island Shipyard.

CHARLES HENRY FARNHAM (Assoc. M. '04) of Pepperell, Mass., died there on June 11, 1938, at the age of 63. Mr. Farnham's career was spent in foreign service—first as assistant engineer for the Isthmian Canal Commission and, later, on railroad construction work in China and the Philippines. Returning to the United States, he became vice-president of the William M. Bailey Company, of Boston, Mass., and for fifteen years prior to his retirement (in 1936) he was assistant superintendent for the State Industrial School at Shirley, Mass.

EDWIN WESLEY HESS (M. '13) consulting civil and mining engineer of Clearfield, Pa., died there on May 27, 1938, at the age of 69. For thirty-five years Mr. Hess maintained his practice in Clearfield, serving as consultant for a number of boroughs and constructing many municipal and public improvements. For twenty-five years of this period he also served as city engineer of Clearfield.

KARL EMIL HILGARD (M. '90) consulting engineer of Zurich, Switzerland, died on June 21, 1938, at the age of 80. Dr. Hilgard, who was well known both in this country and abroad, had maintained his consulting practice in Zurich for many years. He was one of the oldest members of the Society, and on numerous occasions served as its delegate at various functions abroad.

HERBERT McDONALD HINCKLEY (Assoc. M. '29) designing engineer for the Virginia Bridge Company at Roanoke, Va., died suddenly at his home in Salem, Va., on June 27, 1938. He was 41.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

From 1914 to 1920 Mr. Hinckley was draftsman and checker for the Mosher Steel and Machinery Company, of Dallas, Tex., and from 1924 to 1933 he was designer and structural engineer for R. O. Jameson, of the same city. For the past year he had been connected with the Virginia Bridge Company.

GEORGE VOLNEY RHINES (M. '10) architect and structural engineer of Toledo, Ohio, died suddenly at his home in that city on June 29, 1938, at the age of 62. From 1912 to 1930 Mr. Rhines was a member of the architectural firm, Mills, Rhines, Bellman, and Nordhoff, Inc., and from 1930 to his death he was vice-president of the firm. Mr. Rhines did pioneer work on reinforced concrete and was the author of numerous articles.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From June 10 to July 9, 1938, Inclusive

Additions to Membership

Anderson, Robert Wilson (Jun. '38), 109 County St., South Attleboro, Mass.

Bargar, Joseph Lowell (Jun. '38), Asst. Engr. (Civ.), U. S. Engr. Office, Fort Peck Dist., Harlem, Mont.

Barnes, William Wright, Jr. (Jun. '37), 102 West 18th St., Austin, Tex.

Brinkler, John Stanley (Assoc. M. '38), Topographic Draftsman, U. S. Engr. Office, 540 Federal Bldg., Buffalo, N.Y.

Campbell, Elmer Wilmot (Assoc. M. '38), Director, Div. of San. Eng., State Dept. of Health, State House, Augusta, Me.

Campbell, John Rutherford (Assoc. M. '37) Engr., FSA, 700 Stewart Ave., Ithaca, N.Y.

Cascino, David Dominic (Jun. '38), Structural Engr., Foster-Wheeler Eng. Corporation, 6 Church St., New York, N.Y. (Res., 176 Malcolm Ave., Garfield, N.J.)

Cedergren, Harry Roland (Jun. '37), Route 8, Box 827-A, Seattle, Wash.

Cheatham, Robert Arthur (Jun. '38), Route 2, Box 39, Olympia, Wash.

Clark, James Benton (Jun. '38), 17 Walnut St., Evansville, Ind.

Collins, Howard William (Jun. '38), Draftsman, The Texas Co. (Res., 2048 Procter St.), Port Arthur, Tex.

Davies, Samuel Ladd (Jun. '38), Engr., State Board of Health, Little Rock, Ark.

Ebersole, Gordon Keith (Jun. '38), Junior Instrumentman, Grade 9, U. S. Bureau of Reclamation, Neppel, Wash.

Fetter, Roy Eugene (Assoc. M. '38), Asst. Bridge Engr., Bridge Dept., State Div. of Highways, Box 1499, Sacramento, Calif.

Fox, Robert Waldo (Assoc. M. '38), Chf. of Party and Inspecting Engr., Holway & Neuffer, 451 North Miller, Vinita, Okla.

Fretts, Wallace Van Rensselaer (M. '38), Cons. Engr. (Fretts, Tallamy & Senior), 5488 Main St., Williamsville, N.Y.

Gribok, Peter (Jun. '38), 645 East 9th St., New York, N.Y.

Hatch, Graham McFie, Jr. (Jun. '38), San. Engr. and Asst. Chf., Inspection and Sanitation Div., Public Health Dept., 202 City Hall Annex, Dallas, Tex.

Hertzler, Richard Adin (Jun. '38), Supt., Coweeta Experimental Forest, U. S. Forest Service, Appalachian Forest Experiment Station, Route 1, Dillard, Ga.

Herzik, Melvin Clyde (Jun. '38), Box 297, Aspermont, Tex.

ohnston, Hugh Wellford (Jun. '38), Draftsman, Norfolk South. R.R., Norfolk, Va.

Keyes, Richard Jay (Jun. '37), 30 Hamilton Ave., Mount Vernon, N.Y.

Krawitz, Ira (Jun. '38), Junior Engr., U. S. Engr. Corps, U. S. Engr. Office, Rock Island, Ill.

Lager, Fred (Jun. '37), 2805 Grand Concourse, New York, N.Y.

Lambert, Howard William (Jun. '38), Acting Supt., Dept. of Interior, Div. of Grazing, Camp DG-67, Fort Churchill, Weeks, Nev.

LeFever, Floyd Frank (Assoc. M. '38), Asst. Engr., U. S. Geological Survey, Room 3, U. S. Court House, Santa Fé, N. Mex.

Loud, Edward Inman, Jr. (Jun. '38), 20 Front St., Weymouth, Mass.

McInnis, John Lawson, Jr. (Jun. '38), 2030 Ninth Ave., South, Quinlan Castle, Birmingham, Ala.

Morrison, John Allan (Jun. '38), 2d Lieut., Corps of Engrs., U. S. A., 3 Arnold Hall, Fort Riley, Kans.

Nelson, Martin Emil (M. '38), Associate Engr., U. S. Engr. Office, Hydraulic Laboratory, Iowa City, Iowa.

Paddock, Fred William (Jun. '38), Box 92, Las Cruces, N. Mex.

Parmé, Alfred Lucien (Jun. '38), Asst. Engr., U. S. Engrs., U. S. Engr. Office, Security Mutual Bldg., Binghamton, N.Y.

Reickert, Frederick Arthur (Jun. '38), 86 Mansfield St., New Haven, Conn.

Reilly, William Chester (Jun. '37), 1838 East 24th St., Brooklyn, N.Y.

Reinhold, Richard Samuel (Jun. '38), 80 C St., Salt Lake City, Utah.

Reitz, Ben Bone (Jun. '38), 968 Bronx Park South, New York, N.Y.

Robbins, James Melvin (Assoc. M. '38), Asst. Prof., Civ. Eng., Newark Coll. of Eng., Newark (Res., 98 Cypress St., Maplewood), N.J.

Saturnino Rodrigues de Brito, Francisco, Jr. (M. '38), Cons. Engr., Caixa Postal 1631, Rio de Janeiro, Brazil.

Searl, Thomas Dickinson (M. '38), Chf. Constr. Engr., George A. Fuller Co., 597 Madison Ave., New York (Res., 93 Rose Ave, New Dorp), N.Y.

Shea, Carter Laurence (Jun. '38), Civ. Engr., Frederick Snare Corporation, Whitestone (Res., 189–10 Thirty-seventh Ave., Flushing), N.Y.

Sheahan, Harold Vose (M. '38), Treas., Ames-Sheahan, Inc., 47 Prospect St., Somersworth, N.H.

Smith, John Edward (Jun. '38), Chainman, Stone & Webster Constr. Co., Cambridge (Res., Converse Rd., Marion), Mass.

Stanley, Le Roy Sylvester (Assoc. M. '38), Contr's. Engr., McLain Constr. Corporation (Res., 111 Cunard Rd.), Buffalo, N.Y.

Thal, Donald Edward (Jun. '38), Design Engr., Link-Belt Co. (Res., 294 Carl St.), San Francisco, Calif.

Tyburski, Edward Adam (Jun. '38), In Chg of Eng., Town of Rotterdam, Rotterdam (Res., 946 Adams St., Schenectady), N.Y.

Vassalotti, Frank John (Jun. '38), Junior Draftsman, Pennsylvania Water & Power Co., 1512 Lexington Bldg., Baltimore, Md.

Weldy, Raymond Nicholas (Assoc. M. '38), Asst. Hydr. Engr., Union Elec. Co. of Missouri, Eldon, Mo.

Wilcox, Harry Earle (Assoc. M. '38), Civ. Engr., Box 7, Edinburg, Tex.

Willes, Emery Hyde (Jun. '38), 1073 Norris Pl., Salt Lake City, Utah.

Williams, Adrian Harry (Assoc. M. '38), Asst. Engr., U. S. Geological Survey, Water Resources Branch, 526 Federal Bldg., Albany, N.Y.

Williams, Lawrence Perry (Jun. '37), 553 Grant St., Franklin, Pa.

TOTAL MEMBERSHIP AS OF JULY 9, 1938

Members	5,667
Associate Members	6,263
Corporate Members	11,930
Honorary Members	24
Juniors	3,747
Affiliates	78
Fellows	1
Total	15,780

Wright, John Robert (Jun. '37), 2134 State St., Quincy, Ill.

Membership Transfers

Barker, Charles Love (Jun. '29; Assoc. M. '38), Asst. Prof., Hydr. Eng., Coll. of Eng., State Coll. of Washington, Pullman, Wash.

Beer, Robert Gardiner (Jun. '28; Assoc. M. '38), Asst. Prof., Civ. Eng., Polytechnic Inst. of Brooklyn, 99 Livingston St. (Res., 315 Ditmas Ave.), Brooklyn, N.Y.

Camp, Fred Albert (Jun. '31; Assoc. M. '38), Junior Civ. Engr., Dept. of Water and Power, City of Los Angeles, Cain Ranch, Box F, Bishop, Calif.

Copeland, Ray Edwin (Jun. '28; Assoc. M. '38), Sales Engr., Carnegie-Illinois Steel Corporation, 208 South La Salle St., Room 1602, Chicago, Ill.

Daniels, Francis Wallin (Assoc. M. '30; M. '38), Chf. Engr., H. K. Ferguson Co., Hanna Bldg. (Res., 3541 Lytle Rd., Shaker Heights), Cleveland, Ohio.

Edwards, Frank William (Jun. '30; Assoc. M. '38), Chf. of Hydr. Section, U. S. Engr. Office, 2d New Orleans Dist., New Orleans, La.

Fay, Albert James (Jun. '33; Assoc. M. '38), Lieut., C.E.C., U.S.N., Naval Operating Base, Norfolk, Va.

Freeburn, Harry Mortimer (Assoc. M. '26; M. '38), Dist. Engr., Pennsylvania Dept. of Health, 303 Keystone Bldg. (Res., 437 West School Lane, Germantown), Philadelphia, Pa.

Goodwin, Albert Burke (Jun. '28; Assoc. M. '38), Asst. Engr., U. S. Geological Survey, Room 3, U. S. Court House, Santa Fé, N. Mex.

Hoffman, Gerald Henry (Jun. '31; Assoc. M. '38), Engr., Constr. Dept., Johns-Manville Corporation, 1000 Market St. (Res., 5937 McPherson Ave.), St. Louis, Mo.

Howard, John Wilbur (Assoc. M. '29; M. '38), Asst. Prof., Civ. Eng., Coll. of Eng., Univ. of Idaho (Res., 824 East 1st St.), Moscow, Idaho.

Josephs, Arthur Cook (Jun. '28; Assoc. M. '38), Designer, Phoenix Eng. Corporation, 2 Rector St. (Res., Hotel Shelton, 48th St. and Lexington), New York, N.Y.

Kelson, Mihills Olie Courtney (Jun. '30; Assoc. M. '37), Asst. Engr., Federal Power Comm., Room 800, Central Savings Bank Bldg., Denver, Colo.

McCrosky, Theodore Tremain (Jun. '24; Assoc. M. '34; M. '38), Project Adviser, USHA, Dept. of the Interior, 228 West 71st St., New York, N.Y.

Marks, Edwin Hall (Jun. '13; Assoc. M. '16; M. '38), Col., Corps of Engrs., U. S. A.; Dist. Engr., U.S. Engr. Office, 540 Federal Bldg., Buffalo, N.Y.

Morris, Theodore (Jun. '31; Assoc. M. '38), Asst. Engr., Mountain Water Supply Co., 15 North 32d St., Room 415 (Res., Worthington Rd., Somerton), Philadelphia, Pa.

Oliver, William Albert (Jun. '25; Assoc. M. '29; M. '38), Asst. Prof., Civ. Eng., Univ. of Illinois, 402 Eng. Hall, Univ. of Illinois, Urbana, Ill.

Page, Nolan (Jun. '29; Assoc. M. '38), Associate Engr., U. S. War Dept., Hydraulic Laboratory (Res., 17 Woolf Ave.), Iowa City, Iowa.

Perry, Anthony John (Jun. '29; Assoc. M. '38), Asst. Engr., U. S. Bureau of Reclamation, U. S. Custom House, Denver, Colo.

Poole, William Clayton (Jun. '28; Assoc. M. '38), Test and Records Engr., The Texas Co., Box 712, Port Arthur, Tex.

Rector, Nelson Hamilton (Assoc. M. '28; M. '38), Asst. State Director, Malaria Control, State Board of Health (Res., 1416 Robinson St.), Jackson, Miss.

Renshaw, John Arthur (Assoc. M. '27; M.

'38), Res. Engr. Insp., PWA, 111 Board of Education, Philadelphia (Res., 36 Saxer St., Springfield), Pa.

Scruggs, Edwin Lyle (Assoc. M. '19; M. '38), Chf. Engr. and Director, The Springs Cotton Mills (Res., 209 Carol St.), Lancaster, S.C.

Simpson, Charles Randolph (Jun. '09; Assoc. M. '12; M. '38), Contr. Engr. (Simpson & Brown), 90 West St., New York, N.Y.

Stubbs, Frank Whitworth, Jr. (Assoc. M. '27; M. '38), Prof. and Head of Dept. of Civ. Eng., Rhode Island State Coll., Kingston, R.I.

Thorson, Edward William (Jun. '34; Assoc. M. '38), Dist. Structural Engr., Portland Cement Assoc., 408 Hubbell Bldg. (Res., 2825 West Grand Ave.), Des Moines, Iowa.

Williamson, Edwin Paul (Jun. '29; Assoc. M. '38), Senior Eng. Aide, Corps of Engrs., U. S. A.; U. S. Engr. Field Office, Quarterboat 344, 211 North Orange St., Havana, Ill.

Woods, Robert James, Jr. (Jun. '31; Assoc. M. '38), Sales Engr., Steel Constr. Dept., Jones & Laughlin Steel Corporation, 1 Austin Ave. (Res., 1451 Monroe, Apartment 1), Memphis, Tenn.

Reinstatements

Berba, Alexander, Jr., Assoc. M., reinstated June 22, 1938.

Resignations

Engle, Francis George, Assoc. M., resigned June 20, 1938.

Ovenshine, Eugene Samuel, Assoc. M., resigned June 17, 1938.

Rexworthy, Edward Sibree, Jun., resigned June 22, 1938.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

August 1, 1938 Number 8

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in Civil Engineering *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

Grade	General Requirement	Age	Length of Active Practice	Responsible Charge of Work
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years†	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.

† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

MEMBER

Adams, Philip Ernest, Walkerville, Ont., Canada. (Age 51.) Designing Engr., The Canadian Bridge Co. Ltd. Refers to C. M. Goodrich, O. E. Hovey, H. D. Hussey, W. Pope, J. A. Van den Broek, T. T. Whittier.

Breneman, John William, State College, Pa. (Age 37.) Asst. Prof., Dept. of Mechanics and Materials of Constr., Pennsylvania State Coll. Refers to P. B. Breneman, C. L. Harris, R. O'Donnell, R. L. Sackett, H. B. Shattuck, E. D. Walker, L. W. Whitehead.

Epperson, LeRoi R., Atlanta, Ga. (Age 39.) Senior Res. Engr., Georgia State Highway Board, in charge of work in Fulton and DeKalb counties. Refers to B. L. Crenshaw, W. D. Hull, C. A. Marmelstein, M. L. Shadburn, S. B. Slack, C. W. Wright.

Ferguson, Harley Bascom, Vicksburg, Miss. (Age 62.) Pres., Mississippi River Comm., and Div. Engr., Lower Mississippi Valley Div., in charge of all engineering. Refers to J. S. Allen, C. S. Boardman, G. R. Clemens, J. F. Coleman, J. R. Fordyce, A. Marston, G. H. Matthes.

Hatchett, Joseph Morton, Petersburg, Va. (Age 37.) City Engr. Refers to J. A. Anderson, W. Mahone, Jr., M. P. Taylor, W. G. B. Thompson, H. A. Yancey.

Johnson, Elmer George, Detroit, Mich. (Age 35.) Inspector of heavy construction, City of Detroit. Refers to C. L. Allen, C. M. Cade, R. W. Lambrecht, F. C. Morse, F. E. Simpson, L. C. Wilcoxen.

Miller, Clarence Harold, St. Louis, Mo. (Age 36.) Senior Control Engr., Constr. Div., Farm Security Administration, Washington, D.C. Refers to L. T. Berthe, E. E. Bloss, L. B. Feagin, F. L. Flynt, W. W. Horner, C. S. Pineo, P. F. Rossell, H. A. Whitcomb, F. C. Woermann.

Thiel, Charles Joseph, Dayton, Ky. (Age 44.) County Engr. for Campbell County, Ky. Refers to W. L. Glazier, A. Lenderink, C. W. Lovell, R. R. Pyne, M. D. Ross, J. S. Watkins.

Thomson, Herbert Serrell, Jr., West New Brighton, N.Y. (Age 38.) Deputy Director, Div. of Employment, WPA. Refers to D. F. Giboney, J. P. H. Perry, V. H. Reichelt, B. B. Somervell, D. B. Steinman, J. M. Webster, W. J. Wilgus.

Wight, Harry James, Knoxville, Tenn. (Age 57.) Refers to L. C. Bailey, C. N. Bass, A. J. Bottiger, H. H. Hale, W. F. Moehlman, R. B. Newman, Jr.

ASSOCIATE MEMBER

Aivazian, Harry, New York City. (Age 36.) Engr., WPA, Dept. of Parks. Refers to R. E. Horton, H. R. Leach, C. H. MacCulloch, G. J. Requardt, M. E. Scheidt, B. L. Smith, E. B. Whitman.

Altman, Richard, Los Angeles, Calif. (Age 33.) Associate Engr., U. S. Engr. Office. Refers to F. F. Friend, T. G. MacCarthy, D. W. Morrison, R. A. Smith, L. R. Young.

Beall, James Faulkner, Jr., Memphis, Tenn. (Age 32.) Assoc. Engr., Gen. Eng. Div., U. S. Engr. Office, being First Asst. to Head of Levee Planning Sec. Refers to V. M. Cone, A. S. Fry, L. L. Hidinger, F. I. Louckes, B. E. Morriss, L. F. Reynolds, B. A. Ross.

Downey, William Richard, Detroit, Mich. (Age 31.) Senior Instrumentman, Road Survey Div., Michigan State Highway Dept. Refers to L. F. Crowley, J. A. Fox, W. D. McFarland, W. H. Starkweather, F. E. Weber, W. S. Wolfe.

Hveem, Francis Nelson, Sacramento, Calif. (Age 40.) Testing Engr., Materials and Research Dept., California Div. of Highways. Refers to J. E. Buchanan, R. M. Gillis, F. J. Grumm, L. I. Hewes, J. G. Meyer, T. E. Stanton, Jr., R. H. Wilson.

Lange, Fred Carl, Chicago, Ill. (Age 34.) Designer, Eng. Dept., Fabricating Div., Bethlehem Steel Co. Refers to C. H. Harlan, W. E. LaBelle, R. MacMinn, H. M. Pitney, W. E. Robey.

Morgan, Frank Douglas, Hermiston, Ore. (Age 32.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore, H. A. Rands.

Smith, Kenneth Alexander, New York City. (Age 33.) Asst. Prof. of, and Associate in, Architecture, School of Architecture, also Head of Constr. Dept., Columbia Univ. Refers to J. W. Barker, C. A. Egner, J. K. Finch, A. T. Glassett, W. J. Krefeld, R. I. Land, C. A. Selby, D. T. Webster, R. P. Westerhoff.

Thomas, Henry Hardstaff, Manly (Sydney), N.S.W., Australia. (Age 27.) Eng. Draftsman, Designing Engrs. Brancn, Metropolitan Water, Sewerage & Drainage Board, Sydney. Refers to W. A. Miller, T. B. Nicol, H. M. Sherrard. (Applies in accordance with Sec. 1, Art. I, of the By-Laws.)

Willoughby, Graham Paul, Florence, Ala. (Age 35.) Refers to H. D. Burnum, J. A. C. Callan, H. H. Houk, R. D. Jordan, C. A. Wilmore, W. N. Woodbury.

JUNIOR

Ackerson, Duane Wright, Milwaukie, Ore. (Age 22.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

Agnano, Paul, Ardsley, N.Y. (Age 27.) Refers to L. V. Carpenter, A. G. Hayden, C. T. Schwarze, D. S. Trowbridge, H. E. Wessman.

Ali, Raymond Nicholas, Pittsburgh, Pa. (Age 21.) Refers to F. A. Barnes, J. E. Perry.

Allen, Arthur Egbert, Sewickley, Pa. (Age 21.) Refers to F. J. Evans, F. M. McCullough, C. B. Stanton, H. A. Thomas.

Anderson, Kenneth Ward, Portland, Ore. (Age 22.) Refers to J. R. Griffith, L. Griswold, M. O. C. Kelson, F. Merryfield, C. A. Mockmore.

ANDREOPOULOS, THEODORE CHARLES, Worcester, Mass. (Age 21.) Refers to A. H. Holt, J. W. Howe, A. J. Knight.

BARBAROSSA, NICHOLAS LEONARD, Watertown, Mass. (Age 22.) Refers to J. B. Babcock, 3d, J. D. Mitsch.

BARBER, ARTHUR HOUGHTON, JR., Charlotte, N.C. (Age 26.) Refers to F. A. Barnes, C. L. Walker.

BARBER, JOHN THOMAS, Carlsbad, N.Mex. (Age 26.) Refers to F. Bass, A. S. Cutler.

BASSETT, DONALD ARTHUR, Champaign, Ill. (Age 20.) Refers to H. E. Babbitt, J. J. Doland, W. C. Huntington.

BATES, WILLIAM FULTON, Greenville, Miss. (Age 26.) Area Engr., WPA, in charge of malaria control in Washington, Bolivar, Sunflower, and Leflore counties. Refers to N. W. Bowden, F. H. Conley, R. L. Moore, R. H. Pedigo, P. A. Perrin, F. W. Truss, G. D. Whitmore.

BECK, EDWARD ADAM, Lynchburg, Va. (Age 22.) Refers to R. B. H. Begg, R. W. B. Hart, D. H. Pletta, A. J. Saville.

BEECH, DANIEL RAYMOND, Pittsburgh, Pa. (Age 28.) Refers to F. J. Evans, F. M. McCullough, C. B. Stanton, H. A. Thomas.

BELSHAW, DERWIN GEORGE, Jordanville, N.Y. (Age 22.) Refers to L. W. Clark, H. B. Compton, H. O. Sharp.

BERGMAN, MARK LESLIE, Hollis, N.Y. (Age 21.) Refers to D. S. Trowbridge, H. E. Wessman.

BERRY, MYRON SECRIST, Ames, Iowa. (Age 21.) Special Agt., Driver and Observer, U. S. Bureau of Public Roads (Iowa Eng. Experiment Station), Iowa State Coll. Refers to R. A. Caughey, A. H. Fuller, F. Kerekes, R. A. Moyer.

BETHEL, JOHN SOUTHWORTH, JR., Watertown, Mass. (Age 21.) Refers to T. R. Camp, J. D. Mitsch.

BISHOP, EDGAR WAYNE, Linden, N.J. (Age 26.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

BODMAN, JOSEPH DAY, Brooklyn, Wash. (Age 23.) Refers to C. L. Barker, H. E. Phelps, M. K. Snyder.

BONIN, CHARLES CLEMENS, Yonkers, N.Y. (Age 21.) Refers to A. W. French, A. H. Holt, A. J. Knight.

BOWMAN, DON CEYLON, JR., St. Louis, Mo. (Age 22.) Refers to C. F. S. Bardsley, D. C. Bowman, J. B. Butler, E. W. Carlton.

BOWMAN, GREYDON WEST, Detroit, Mich. (Age 23.) Asst. Instrumentman and Rodman, George Jerome & Co. Refers to C. C. Johnston, C. J. J. Pajot.

BRADY, EMMETT EDWARD, Los Gatos, Calif. (Age 21.) Refers to E. C. Flynn, G. L. Sullivan.

BRAVO, ARTHUR CHARLES, Petaluma, Calif. (Age 23.) Refers to E. C. Flynn, G. L. Sullivan.

BREWER, FRANCIS MARION, Jackson, Miss. (Age 23.) Steel Detailer and Designer, Ellis Supply Co. Refers to J. C. Bridger, D. M. McCain.

BROOKS, JACK DICKERSON, Boulder, Colo. (Age 29.) Refers to R. L. Downing, C. L. Eckel.

BROWN, RUSSELL HAYWARD, West Roxbury, Mass. (Age 21.) Refers to J. B. Babcock, 3d, J. D. Mitsch.

BROWN, WILLIAM JOSEPH, Newark, N.J. (Age 21.) Refers to H. N. Cummings, W. S. LaLonde, Jr., R. W. Van Houten.

BULKLEY, ROBERT ALDRICH, Wray, Colo. (Age 22.) Refers to R. L. Downing, C. L. Eckel, E. W. Raeder.

BURK, JOHN SEYBURN, New Orleans, La. (Age 21.) Refers to E. S. Bres, D. Derickson.

CARLOCK, HOWARD JOSEPH, New York City. (Age 22.) Refers to D. S. Trowbridge, H. E. Wessman.

CARNEGIE, ORRIS ALVIN, Albany, Ore. (Age 22.) Refers to G. W. Holcomb, F. Merryfield.

CARROLL, ROGER MERLE, Maplewood, N.J. (Age 24.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

CHAFFEE, DONALD LESTER, Liberty, N.Y. (Age 24.) Refers to F. A. Barnes, J. E. Perry.

CHAMBERLIN, CARL HAL, San Diego, Calif. (Age 23.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

CHANDLER, WILLIAM REEDER, Seattle, Wash. (Age 25.) Refers to G. E. Hawthorn, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

CHASE, ALFRED LEROY, Lincoln, Nebr. (Age 22.) Refers to C. M. Duff, D. H. Harkness, H. J. Kesner, C. E. Mickey.

CHUDOBA, ALBERT LAWRENCE, Brooklyn, N.Y. (Age 23.) Refers to D. M. Burmister, J. K. Finch, W. J. Krefeld.

CLADNY, HAROLD, WASHINGTON, D.C. (Age 21.) Refers to H. R. Hall, C. A. Hechmer, S. S. Steinberg.

CLARK, BYRON JAMES, Seattle, Wash. (Age 21.) Refers to G. E. Hawthorn, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. B. Van Horn.

CLOUES, RICHARD WENUELL, Shrewsbury, Mass. (Age 21.) Refers to A. W. French, A. H. Holt, J. W. Howe, A. J. Knight.

COCCHIARELLA, OTELL MARIO, Newark, N.J. (Age 22.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

COLLIE, ROBERT MONROE, Pecos, Tex. (Age 22.) Refers to J. T. L. McNew, J. J. Richey.

CONWAY, GERALD RICHARD, Rockaway Beach, N.Y. (Age 23.) Refers to C. T. Bishop, R. H. Suttie.

CRAIG, KENNETH JOHN, Rapid City, S.Dak. (Age 23.) Refers to A. A. Chenoweth, E. D. Dake.

CRAUMER, RICHARD LISLE, Lebanon, Pa. (Age 23.) Refers to E. D. Walker, L. W. Whitehead.

CROOKER, JOHN TWINAME, Fresno, Calif. (Age 25.) Refers to F. H. Fowler, S. B. Morris, L. B. Reynolds, E. C. Thomas, J. B. Wells, H. A. Williams.

CROSBY, SHELBY TAYLOR, Austin, Tex. (Age 26.) Refers to E. C. H. Bantel, J. A. Focht.

CYPHERS, ROBERT ELLSWORTH, JR., East Orange, N.J. (Age 22.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

DAVIDOFF, JAMES EUGENE, St. Paul, Minn. (Age 22.) Refers to F. Bass, A. S. Cutler.

DAVIS, WILLIAM, Duquesne, Pa. (Age 24.) Refers to A. Diefendorf, L. C. McCandliss.

DEGEER, MYRON WINTERSTEIN, Lake City, Kans. (Age 26.) Refers to L. E. Conrad, F. F. Frazier, M. W. Furr, R. F. Morse, C. H. Scholer.

DELONG, LAWRENCE MERTON, Portland, Ore. (Age 23.) Refers to J. R. Griffith, F. Merryfield.

DENTON, CHARLES EDWARD, Carthage, Ill. (Age 22.) Refers to N. D. Morgan, C. E. Palmer.

DIKE, CHARLES ANTHONY, Seattle, Wash. (Age 24.) Refers to R. G. Hennes, A. L. Miller, C. C. More, F. H. Rhodes, Jr., F. C. Smith, R. G. Tyler, R. B. Van Horn.

DODGE, EARNEST FARWELL, Portland, Ore. (Age 25.) Refers to R. G. Hennes, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

DONALDSON, PAUL BLAIR, Rapid City, S.Dak. (Age 22.) Refers to A. A. Chenoweth, E. D. Dake

DRUCKER, DANIEL CHARLES, New York City. (Age 20.) Refers to J. K. Finch, W. J. Krefeld.

DURFEE, CHARLES DENSMORE, JR., Yonkers, N.Y. (Age 22.) Refers to D. S. Trowbridge, H. E. Wessman.

DURNIN, ALBERT WARD, Ithaca, N.Y. (Age 21.) Refers to E. F. Berry, L. Mitchell.

EPSTEIN, EDWIN HEINEMAN, San Francisco, Calif. (Age 21.) Chainman, San Francisco Bay Exposition. Refers to C. Derleth, Jr., C. T. Wiskocil.

EPSTEIN, RAYMOND, Chicago, Ill. (Age 20.) Refers to H. E. Babbitt, J. S. Crandell, A. Epstein.

ERICKSON, EDWIN MILTON, Brooklyn, N.Y. (Age 21.) Refers to L. F. Rader, E. J. Squire.

ERICSON, JOHN MILTON, Peoria, Ill. (Age 26.) Refers to H. E. Babbitt, J. J. Doland, W. C. Huntington, G. W. Pickels, T. C. Shedd.

ESPER, FREDERICK, Worcester, Mass. (Age 22.) Refers to A. W. French, A. H. Holt, J. W. Howe, A. J. Knight.

FENSTERMAKER, CHARLES HOWARD, JR., Elizabeth, La. (Age 21.) Refers to B. W. Pegues, F. F. Pillet

FERBER, PAUL LUDWIG, Hackensack, N.J. (Age 22.) Refers to C. T. Bishop, R. H. Suttie.

FLOYD, ROBERT, Elmira, N.Y. (Age 23.) Draftsman, American Bridge Co. Refers to E. F. Berry, L. Mitchell, H. W. Preston, S. D. Sarason, G. D. Westra.

FLYNN, WILLIAM SCHILLING, Troy, N.Y. (Age 26.) Sales Representative, Sales Dept., Eddy Valve Co., Waterford, N.Y. Refers to F. J. Keis, J. Knickerbacker.

FORMAN, FRED PATON, Ridgewood, N.J. (Age 23.) Refers to J. B. Babcock, 3d, J. D. Mitsch.

GABACCIA, ALDO JOSEPH, Woodcliff Lake, N.J. (Age 22.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

GAILEN, LAWRENCE EDWIN, Chicago, Ill. (Age 24.) Refers to N. D. Morgan, C. E. Palmer.

GALE, JAMES MCNICHOL, Palatka, Fla. (Age 21.) Refers to T. M. Lowe, P. L. Reed.

GALLAGHER, JOHN HUBERT, JR., Portland, Ore. (Age 24.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

GARRISON, CARMAN WILLIAM, Newark, N.J. (Age 22.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

GAUL, JOHN WILCOX, Kenmore, N.Y. (Age 22.) Refers to F. A. Barnes, J. E. Perry.

GAVIRIA TAMAYO, LUIS GILBERTO, Medellin, Antioquia, Colombia. (Age 24.) Refers to A. B. Hargis, F. V. Ragsdale.

GEFFEL, JOHN CHARLES, Pittsburgh, Pa. (Age 25.) Refers to C. G. Dunnells, F. M. McCullough.

GENTLE, ERNEST JAMES, Spokane, Wash. (Age 24.) Refers to A. L. Miller, C. C. More, F. H. Rhodes, Jr., F. C. Smith, R. G. Tyler, R. B. Van Horn.

GOEKE, HAROLD EVERETT, Dixon, Ill. (Age 22.) Refers to J. J. Doland, M. L. Enger, W. C. Huntington, H. H. Jordan, T. C. Shedd, J. Vawter, C. C. Wiley.

GOODWIN, RICHARD SMITH, East Liverpool, Ohio. (Age 22.) Refers to F. A. Barnes, R. Y. Thatcher.

GOWDEY, DWIGHT MAYNARD, Seattle, Wash. (Age 21.) Refers to R. G. Hennes, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

GRAHAM, DOYLE ELIJAH, Rapid City, S.Dak. (Age 27.) Refers to A. A. Chenoweth, E. D. Dake.

GRANT, FRANCIS WEIR, Shreveport, La. (Age 29.) Engr. with City of Shreveport. Refers to J. J. A. Kelker, J. T. L. McNew, T. P. Quinn, R. L. Tatum, W. M. Werner.

GRAVES, CHARLES LEONIDAS, JR., Louisville, Ky. (Age 22.) With Modjeski & Masters, Cons. Engrs., Harrisburg, Pa., as Field Engr. and Inspector on Ohio River Bridge, Cairo, Ill. Refers to W. R. McIntosh, W. B. Wendt.

GRAY, EDWARD ZIGMUND, Portland, Ore. (Age 22.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

GRIMM, NELWIN CLEATIS, Tolono, Ill. (Age 23.) Refers to G. H. Dell, J. J. Doland, W. A. Oliver, G. W. Pickels, T. C. Shedd.

GUARD, CHARLES LEWIS, JR., Lebanon, Ohio. (Age 22.) Refers to C. T. Morris, J. C. Prior, J. R. Shank, C. E. Sherman, R. C. Sloane.

GUILLARD, EUGENE, Urbana, Ill. (Age 26.) Refers to J. J. Doland, W. C. Huntington.

HAM, ALTON SINCLAIR, Bangor, Maine. (Age 25.) Refers to W. S. Evans, E. H. Sprague.

HAMNER, BENNETT BARRON, Waco, Texas. (Age 23.) Refers to J. T. L. McNew, J. J. Richey.

HANSON, ODIN SIGVARD, Grand Forks, N.Dak. (Age 22.) Refers to A. Boyd, E. F. Chandler.

HARSTAD, HOWARD THEODORE, Puyallup, Wash. (Age 21.) Refers to C. W. Harris, G. E. Hawthorn, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

HARTMAN, GEORGE FREDERICK, Seattle, Wash. (Age 25.) Refers to G. E. Hawthorn, R. G. Hennes, C. C. More, F. H. Rhodes, Jr., F. C. Smith, R. G. Tyler, R. B. Van Horn.

HENSLEY, LAURENCE SHERMAN, Milton, W.Va. (Age 24.) Refers to R. P. Davis, W. S. Downs.

HILDERMAN, RICHARD ALAN, Lockport, N.Y. (Age 20.) Refers to L. W. Clark, H. O. Sharp, E. R. Wiseman.

HILPERT, JOHN MEIER, Bethlehem, Pa. (Age 21.) Refers to F. Merryfield, C. A. Mockmore.

HOGLIN, HAROLD ALVIN, Boulder, Colo. (Age 29.) Refers to R. L. Downing, C. L. Eckel, E. W. Raeder, L. B. Sutherland, W. H. Thoman.

HOLLEY, WILLIAM CHIPMAN, Corvallis, Ore. (Age 22.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

HOOVER, LAWRENCE MERRIL, Hood River, Ore. (Age 25.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

HOWARD, EARL ROCKWELL, Burlington, Vt. (Age 23.) Refers to G. P. Eckhard, L. B. Puffer.

HOWLAND, JAMES CHASE, Oregon City, Ore. (Age 22.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

HUTCHINS, XAVIER SUTTON, Louisville, Ky. (Age 22.) Refers to W. R. McIntosh, W. B. Wendt.

JARVI, ALBERT OTTO, Seattle, Wash. (Age 21.) With Eng. Dept., Standard Oil Co of California, San Francisco, Calif. Refers to A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

JEPPESEN, GORDON LUTZ, Champaign, Ill. (Age 24.) Refers to J. J. Doland, T. C. Shedd.

JOHNSON, CHARLES VERNON, Atlanta, Ga. (Age 24.) Refers to C. D. Gibson, F. C. Snow.

JOHNSON, CLIFFORD WILLIAM, Seattle, Wash. (Age 26.) Refers to G. E. Hawthorn, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. B. Van Horn.

JOHNSON, FREDERIC ARTHUR, Minot, N.Dak. (Age 28.) Refers to E. F. Chandler, H. M. Fitch, E. R. Griffin, C. Johnson, L. M. Winsor.

KAFKA, WALTER ADOLPH, Bound Brook, N.J. (Age 22.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

KAYSER, JOHN EDWARD, Copper Cliff, Ont., Canada. (Age 21.) Refers to J. H. Brace, C. E. Fraser, H. Smith, R. H. Suttie, S. H. Woodard.

KENNEDY, ROBERT EVAN, Denver, Colo. (Age 22.) Refers to R. L. Downing, C. L. Eckel.

KERR, ROBERT STANLEY, Inglewood, Calif. (Age 21.) Refers to B. A. Etcheverry, S. T. Harding, J. B. Lippincott, C. T. Wiskocil.

KILE, FRED JAMES, Beloit, Wis. (Age 22.) Refers to N. D. Morgan, C. E. Palmer, T. C. Shedd.

KLASING, WALDEMAR JOHN, St. Louis, Mo. (Age 26.) Refers to W. W. Horner, E. O. Sweetser.

KLAUCK, FREDERICK ROBERT, Niagara Falls, N.Y. (Age 23.) Refers to J. D. Mitsch, D. W. Taylor.

KNEALE, JOHN STEPHEN, JR., Brooklyn, N.Y. (Age 23.) San. Engr. (chemist in charge), New York Water Service Corporation. Refers to H. N. Lendall, G. D. Norcom.

KOCH, SIDNEY, Perth Amboy, N.J. (Age 21.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

KORETSKY, SANFORD, New York City. (Age 23.) Refers to A. G. Hayden, A. P. Richmond, Jr.

KOZAK, ISADORE, East Orange, N.J. (Age 23.) Refers to L. V. Carpenter, D. S. Trowbridge

KULLAS, ALBERT JOHN, JR., Webster, Mass. (Age 21.) Refers to A. W. French, A. H. Holt, J. W. Howe, A. J. Knight.

KUNZ, FOSTER MERLEN, Bern, Idaho. (Age 22.) With Idaho State Highway Dept., Pocatello, Idaho. Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner.

KYLER, JAMES WILLIAM, Jeromesville, Ohio. (Age 22.) Refers to L. H. Gardner, F. L. Gorman, A. R. Webb.

LACY, EDWARD RANDOLPH, Frederick Hall, Va. (Age 20.) Refers to R. B. H. Begg, D. H. Pletta, F. J. Sette.

LANDAU, THOMAS JACOB, Pittsburgh, Pa. (Age 23.) Refers to C. G. Dunnells, F. J. Evans, C. B. Stanton.

LANGDALE, FREDERICK DARROW, Galveston, Tex. (Age 22.) Refers to O. V. Adams, J. H. Murdough, H. N. Roberts.

LANIER, EUGENE BERTRAM, Pittsburg, Kans. (Age 24.) Refers to C. E. S. Bardsley, H. C. Beckman, J. B. Butler, E. W. Carlton, C. V. Mann.

LANNING, ROBERT LAWRENCE, San Bernardino, Calif. (Age 22.) Refers to E. N. Bryan, M. S. Edson, W. E. Stoddard, G. F. Teale, H. J. Whitlock.

LAVEZZOLI, CHARLES LEWIS, Chester, Conn. (Age 22.) Refers to A. W. French, A. H. Holt, J. W. Howe, A. J. Knight.

LEHMAN, FREDERICK GOODWIN, Brooklyn, N.Y. (Age 20.) Refers to W. Allan, W. L. Willig.

LEWIS, NORVIN JOSEPH, San Jose, Calif. (Age 22.) Refers to E. C. Flynn, G. L. Sullivan.

LINDBLOM, LEONARD CARL, Chicago, Ill. (Age 22.) Refers to H. E. Babbitt, J. J. Doland, W. A. Oliver, T. C. Shedd, J. Vawter.

LYMAN, MELVILLE HENRY, JR., Glen Ridge, N.J. (Age 23.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

LYNCH, JAMES ALVIN, Los Angeles, Calif. (Age 25.) Refers to F. O. Rose, D. M. Wilson.

LYNCH, ROBERT GLEN, Los Angeles, Calif. (Age 22.) Refers to F. O. Rose, D. M. Wilson.

MCCANN, FRANK BATES, Hopewell, Va. (Age 23.) Refers to H. C. Bird, W. R. McCann, P. A. Rice.

MCCLARY, JAMES DALY, Boise, Idaho. (Age 21.) Refers to F. T. Crowe, M. Swendsen, W. G. Swendsen, H. A. Williams, G. L. Youmans.

MCCRODDEN, HOWARD JAMES, Brooklyn, N.Y. (Age 21.) Refers to H. R. Codwise, H. P. Hammond, L. F. Rader, A. P. Richmond, Jr., R. Ridgway, E. J. Squire.

MCMAHON, THOMAS EARL, Hermosa, S.Dak. (Age 22.) Refers to A. A. Chenoweth, E. D. Dake.

MCNEIL, BRUCE WILLIAM, Beverly Hills, Calif. (Age 22.) Refers to F. O. Rose, D. M. Wilson.

MCWHORTER, WAYNE WHITTEN, Tremonton, Utah. (Age 25.) Refers to H. S. Carter, G. D. Clyde, O. W. Israelsen, H. R. Kepner.

MAINS, ROBERT MARVIN, Denver, Colo. (Age 20.) Refers to R. L. Downing, C. L. Eckel, B. W. Raeder.

MARKS, FRANCIS JOSEPH, Portland, Ore. (Age 23.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

MARLOWE, DONALD EDWARD, Detroit, Mich. (Age 22.) Rodman and Asst. Instrumentman, Geo. Jerome & Co. Refers to C. C. Johnston, C. J. J. Pajot.

METCALF, LAURENCE REGNELL, Hood River, Ore. (Age 24.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

MILLENSIFER, ROBERT WILLIAM, Denver, Colo. (Age 23.) Refers to R. L. Downing, C. L. Eckel.

MILLS, ARTHUR WILBUR, Springfield, Ill. (Age 26.) Refers to N. D. Morgan, C. E. Palmer.

MITCHELL, JOHN FAWCETT, Salt Lake City, Utah. (Age 22.) With Utah Power & Light Co., in Eng. Dept. Refers to T. C. Adams, R. B. Ketchum.

MOHLER, CHESTER EDMOND, Boulder, Colo. (Age 21.) Refers to R. L. Downing, C. L. Eckel.

MOHR, HERBERT ADOLPH, Hillsboro, Ore. (Age 23.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

MORRIS, ROBERT DEWAR, Portland, Ore. (Age 23.) Refers to J. R. Griffith, F. Merryfield, C. A. Mockmore.

MURRAY, JAMES JOSEPH, Colorado Springs, Colo. (Age 21.) Refers to R. L. Downing, C. L. Eckel, B. W. Raeder, L. B. Sutherland, W. H. Thoman.

NACHAY, JOSEPH, New York City. (Age 20.) Refers to D. S. Trowbridge, H. E. Wessman.

NEWSOME, RICHARD CECILE, Houston, Tex. (Age 24.) Refers to P. M. Ferguson, J. A. Focht.

NOYES, GEORGE ALLEN, Nevada City, Calif. (Age 27.) Refers to B. Jameyson, C. T. Wiskocil.

O'KEEFE, JOHN HERMAN, Detroit, Mich. (Age 22.) Asst. Civ. Engr., John L. Griffiths & Son Constr. Co. Refers to C. C. Johnston, C. J. J. Pajot.

OLSEN, LLOYD THOMAS, West Hempstead, N.Y. (Age 23.) Refers to S. Burnley, T. H. Evans, E. W. Saunders.

OLSON, MARK WALDEMERE, Milaca, Minn. (Age 22.) Refers to F. Bass, A. S. Cutler, L. G. Straub, J. A. Wise.

O'MEALY, BURTON FLOYD, Portland, Ore. (Age 27.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

OPPENHEIM, LOUIS HERMAN, Pleasanton, Calif. (Age 25.) Refers to C. Derleth, Jr., S. M. Munson, C. T. Wiskocil.

OSBORN, EUGENE WALLACE, Staten Island, N.Y. (Age 21.) Refers to F. A. Barnes, J. E. Perry.

OSTERHOUDT, LAWRENCE JAN, New Paltz, N.Y. (Age 23.) Refers to C. E. Fraser, M. O. Fuller, C. D. Jensen, H. G. Payrow, H. Sutherland.

PAHL, RUDOLPH MENTZ, Berkeley, Calif. (Age 30.) Refers to E. C. Thomas, J. B. Wells, H. A. Williams.

PATTABONGSE, CHAROEN, Washington, D.C. (Age 30.) Refers to E. Mirabelli, J. D. Mitsch.

PENMAN, ROBERT RAY, Williston, N.Dak. (Age 24.) Refers to H. M. Fitch, E. R. Griffin.

PERSON, KENNETH WILLIAM, Minneapolis, Minn. (Age 22.) Refers to F. Bass, A. S. Cutler, L. G. Straub.

PETERSEN, JOHN JUNIOR, Tampa, Fla. (Age 25.) Refers to H. Bartholomew, N. D. Morgan, C. E. Palmer.

PIERCE, JAMES ELMER, Atlanta, Ga. (Age 24.) Refers to C. D. Gibson, F. C. Snow.

PIERCE, PAUL FRANCIS, Saunderstown, R.I. (Age 21.) Refers to C. D. Billmyer, F. W. Stubbs, Jr.

PLUMMER, ALBERT WILLIAM, Kirkland, Wash. (Age 22.) Refers to C. W. Harris, R. G. Hennes, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

PONTIUS, ARNOLD BUTLER, Lewiston, Idaho. (Age 23.) Refers to C. L. Barker, W. P. Hughes, W. L. Maloney, H. E. Phelps, M. K. Snyder.

POTTER, JAMES OSCAR, Quincy, Ill. (Age 23.) Refers to H. E. Babbitt, T. C. Shedd.

PROKOPP, EDWARD JOSEPH, Detroit, Mich. (Age 25.) Estimator, J. L. Peters Co., Structural Steel Fabricators. Refers to C. C. Johnston, C. J. J. Pajot.

REGLIN, FREDERICK, JR., Waxahachie, Tex. (Age 22.) Refers to E. C. H. Bantel, J. A. Focht.

REILLY, JOSEPH THOMAS, Vicksburg, Miss. (Age 28.) Eng. Aide (Civ.), Vicksburg Engr. Dist. Refers to O. G. Baxter, P. E. Cunningham, W. E. Elam, W. A. Vaught.

REITTER, ARTHUR RIED, Hastings, Nebr. (Age 29.) Designer, Hydr. Design Dept., Central Nebraska Public Power & Irrigation Dist. Refers to D. A. Buzzell, P. J. Cannell, W. Grant, R. O. Green, J. G. Mason, J. Sorkin, C. E. Spellman.

RENSHAW, CLAUDE DOWNER, Miami Beach, Fla. (Age 21.) Refers to M. N. Lipp, M. Pirnie.

REVELL, RUSSELL WHITTINGTON, Bonanza, Ore. (Age 24.) Refers to F. Merryfield, C. A. Mockmore.

REVERA, HENRY WILK, Irvington, N.J. (Age 25.) Refers to H. N. Cummings, W. S. LaLonde, Jr.

RICHARDS, HARRY WILBER, Molalla, Ore. (Age 23.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

RICKER, EDMUND ROUHAN, Groton, Vt. (Age 22.) Refers to C. S. Farnham, R. H. Suttie.

RITZ, FRANCIS BENJAMIN, Worcester, Mass. (Age 21.) Refers to A. H. Holt, A. J. Knight.

ROBERTSON, JAMES JEFFRIES, Oswego, Ore. (Age 24.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

ROBERTSON, JAMES MUELLER, Urbana, Ill. (Age 22.) Refers to J. J. Doland, W. C. Huntington, G. W. Pickels.

ROOSA, PAUL ROBERT, Boulder, Colo. (Age 22.) Refers to C. L. Eckel, L. B. Sutherland.

ROSATO, FRANK JOSEPH, New Orleans, La. (Age 23.) Refers to E. S. Bres, D. Derickson.

ROSEBRAUGH, VERNON HART, Aloha, Ore. (Age 27.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

RUSSELL, JOSEPH EDGAR, Lemont, Pa. (Age 21.) Refers to J. S. Leister, E. D. Walker, L. W. Whitehead.

RUTH, LEO WILLIAM, JR., San Jose, Calif. (Age 20.) Refers to E. C. Flynn, G. L. Sullivan.

SALCH, LOUIS EDWARD, Bloomington, Ill. (Age 23.) Refers to H. E. Babbitt, W. C. Huntington, T. C. Shedd.

SALGO, MICHAEL NICHOLAS, Blacksburg, Va. (Age 24.) Refers to R. B. H. Begg, G. A. Maney, D. H. Pletta.

SANBORN, EDGAR FRANKLIN, JR., Fishers Island, N.Y. (Age 22.) Refers to C. D. Billmyer, F. W. Stubbs, Jr.

SAWCHUK, HENRY AVERY, BROOKLYN, N.Y. (Age 23.) Public Service Interne, New York City. Refers to W. Allan, L. C. Pope, T. H. Prentice, J. C. Rathbun, W. L. Willig.

SCALZI, JOHN BAPTIST, Hopedale, Mass. (Age 22.) Refers to A. W. French, A. H. Holt.

SCARBOROUGH, RALPH LAMBERT, Hartville,

Mo. (Age 22.) Refers to C. E. S. Bardsley, J. B. Butler.

SCHAPER, ERNEST HENRY, Fortuna, Mo. (Age 24.) Refers to R. B. B. Moorman, H. Rubey.

SCHMIDT, VICTOR RAYMOND, JR., Austin, Tex. (Age 23.) Draftsman, City Water Dept. Refers to E. C. H. Bantel, P. M. Ferguson, S. P. Finch, J. A. Focht, T. U. Taylor.

SCHMIELAU, HENRY ANDREW, Chicago, Ill. (Age 22.) Refers to J. J. Doland, G. W. Pickels, J. Vawter.

SCHRADER, GEORGE PHILIP, JR., Bluefield, W.Va. (Age 22.) Refers to R. B. H. Begg, D. H. Pletta.

SCHWAB, ALVIN RAYMOND, Washington, D.C. (Age 21.) Refers to R. B. H. Begg, D. H. Pletta.

SHEEHAN, WILLIAM MICHAEL, Howard Beach, Queens County, N.Y. (Age 21.) Refers to D. M. Burmister, J. K. Finch, J. M. Garrelts, W. J. Krefeld.

SHELTON, WILLIE CLYDE, La ton, Okla. (Age 24.) Refers to J. F. Brookes, N. E. Wolfard.

SHER, HYMAN HENRY, Los Angeles, Calif. (Age 25.) Refers to N. D. Morgan, C. E. Palmer.

SHERMAN, CLYDE KEENER, Klamath Falls, Ore. (Age 21.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

SHORT, JOHN AUGUST, St. Louis, Mo. (Age 27.) Refers to C. E. S. Bardsley, H. C. Beckman, J. B. Butler, E. W. Carlton, C. V. Mann.

SITLER, WILLARD STANLEY, Sunbury, Pa. (Age 22.) Refers to R. O'Donnell, E. D. Walker, L. W. Whitehead.

SLATTEBO, OSCAR INGVALD, Stanislaus, Calif. (Age 24.) Levelman and on field engineering (under Res. Engr.) for driving 11 miles of tunnel, Pacific Gas & Electric Co., San Francisco, Calif. Refers to C. Derleth, Jr., B. A. Etcheverry.

SMITH, LIVINGSTON SHATTUCK SALISBURY, Providence, R.I. (Age 21.) Refers to J. B. Babcock, 3d, J. D. Mitsch.

SMOUSE, KENNETH JAMES, Ione, Ore. (Age 26.) Refers to J. R. Griffith, G. W. Holcomb, F. Merryfield, C. A. Mockmore.

SOLOMON, CHARLES BORDEN, Fall River, Mass. (Age 21.) Refers to C. D. Billmyer, L. L. Holland, F. W. Stubbs, Jr.

STANTON, ROBERT LOUIS, St. Joseph, Mich. (Age 21.) Draftsman, Berrien County Highway Dept. Refers to J. Anderson, H. G. Crow, L. S. Le Tellier.

STEINAU, ALFRED BERTIN, New Rochelle, N.Y. (Age 26.) Refers to L. V. Carpenter, D. S. Trowbridge, H. E. Wessman.

STOCKMAN, CHARLES EDWARD, Baker, Ore. (Age 26.) Refers to F. Merryfield, C. A. Mockmore.

STONE, WALKER GERHARD, Chicago, Ill. (Age 23.) Refers to N. D. Morgan, C. E. Palmer.

STRICKLAND, WALLACE ALBERT, Lincoln, N.H. (Age 26.) Refers to E. W. Bowler, R. R. Skelton.

SUMMERSETT, JOHN, JR., Portland, Ore. (Age 23.) Refers to G. E. Hawthorn, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

TAFFEL, FRANK, New York City. (Age 20.) Refers to D. S. Trowbridge, H. E. Wessman.

TAYLOR, HAROLD IVOR, JR., Kansas City, Mo. (Age 20.) Refers to G. W. Bradshaw, W. C. McNown.

TAYLOR, WILLIAM RICHARD, Portland, Ore. (Age 24.) Refers to F. Merryfield, C. A. Mockmore.

THROOP, JOSEPH FRANKLIN, Bainbridge, N.Y. (Age 20.) Refers to H. B. Compton, E. R. Wiseman.

TOUBY, HARRY, Miami, Fla. (Age 21.) Refers to T. M. Lowe, P. L. Reed.

TOURITZIN, ALEXANDER MICHAIL, Urbana, Ill. (Age 24.) Refers to E. E. Bauer, J. S. Crandell, W. C. Huntington, G. W. Pickels, C. C. Wiley.

TOWNE, BRUCE EDDY, Peshastin, Wash. (Age 22.) Refers to C. L. Barker, H. E. Phelps, M. K. Snyder, J. G. Woodburn.

TROWBRIDGE, GLENN HAROLD, Newport, Wash. (Age 23.) Refers to C. L. Barker, H. E. Phelps, H. A. Sewell, M. K. Snyder, J. C. Stegner.

TURNER, ROGER PARKHURST, Ft. Worth, Tex. (Age 24.) Refers to E. C. H. Bantel, J. A. Focht.

VIETO, CLAUDE, New York City. (Age 23.) Refers to L. H. Gardner, F. L. Gorman, A. R. Webb.

VOODHIGULA, OUI THIENO, Washington, D.C. (Age 26.) Refers to E. Mirabelli, J. D. Mitsch.

WAGONER, WALTER PRICE, Salisbury, N.C. (Age 20.) Refers to J. Anderson, L. S. Le Tellier.

WALKER, JOHN DELOS, Davenport, Wash. (Age 22.) Refers to C. L. Barker, H. E. Phelps, M. K. Snyder.

WARREN, SAM FLOYD, Apalachicola, Fla. (Age 21.) Refers to T. M. Lowe, P. L. Reed, W. L. Sawyer.

WASYLKIW, MYRON ANTON, New York City. (Age 21.) Refers to D. S. Trowbridge, H. E. Wessman.

WEBER, HAROLD EDWARD, Chicago, Ill. (Age 21.) Refers to N. D. Morgan, C. E. Palmer.

WIKSTROM, VERNER ANTON, Seattle, Wash. (Age 21.) Refers to G. E. Hawthorn, R. G. Hennes, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

WINHOLTZ, WILFORD GARR, Ogden, Utah. (Age 21.) Refers to T. C. Adams, R. B. Ketchum.

WINKELHOLZ, WILLIAM RAY, Bartlesville, Okla. (Age 22.) Refers to F. Dawson, R. B. Kittredge, B. J. Lambert, F. T. Mavis, E. L. Waterman.

WITKEGE, FRANCIS LEO, Worcester, Mass. (Age 21.) Refers to A. W. French, A. H. Holt, J. W. Howe, A. J. Knight.

WITTE, EDWARD GEORGE, Knoxville, Tenn. (Age 26.) Refers to H. B. Luther, W. L. Voorduin, D. M. Wood.

WOLF, HERBERT CHARLES, St. Louis, Mo. (Age 24.) Jun. Engr. with Russell & Axon, Cons. Engrs. Refers to C. E. S. Bardsley, J. B. Butler, E. W. Carlton, J. C. Pritchard, G. S. Russell.

WRIGHT, NEWTON BATEMAN, Denver, Colo. (Age 21.) Refers to C. A. Ellis, R. B. Wiley.

YAYOSHI, MASAO, Seattle, Wash. (Age 24.) Refers to A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. G. Tyler, R. B. Van Horn.

ZUMWALT, PAUL LAWRENCE, Emden, Ill. (Age 26.) Refers to E. E. Bauer, J. Vawter.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

CHRISTOPHER, WILLIS CLINTON, Assoc. M., Mexico, D. F., Mexico. (Elected Aug. 26, 1929.) (Age 49.) Cons. Engr., Comision Nacional de Irrigacion. Refers to J. B. Bond, L. V. Branch, J. L. Burkholder, F. T. Crowe, J. Hinds, A. Weiss, F. E. Weymouth.

JOHNSON, ALBERT EDWIN, Assoc. M., Columbia, S.C. (Elected May 12, 1930.) (Age 41.) Dist. Engr., Water Resources Branch, U. S. Geological Survey. Refers to E. D. Burchard, N. C. Grover, A. W. Harrington, J. C. Hoyt, T. K. Legare, C. G. Paulsen, R. L. Sumwalt.

KASEL, RUDOLPH GUSTAV, Assoc. M., Iowa City, Iowa. (Elected Junior Dec. 15, 1924; Assoc. M. May 12, 1930.) (Age 38.) Hydr. Engr. (Dist. Engr.), U. S. Geological Survey, Water Resources Branch. Refers to H. C. Beckman, F. M. Dawson, A. H. Fuller, N. C. Grover, M. L. Hutton, E. W. Lane, F. T. Mavis, C. G. Paulsen.

KELLY, JOE WALLACE, Assoc. M., Berkeley, Calif. (Elected Dec. 3, 1926.) (Age 43.) Research Engr., Eng. Materials Laboratory, Univ. of California. Refers to R. E. Davis, W. K. Hatt, W. A. Knapp, F. R. McMillan, G. E. Troxell, S. Walker, J. Wilson.

MATTER, LAWSON DEACON, Assoc. M., Kingston, Pa. (Elected June 16, 1924.) (Age 41.) Dist. Engr., Pennsylvania Dept. of Health in charge of Wilkes-Barre Dist. Office. Refers to W. T. Barnes, C. A. Emerson, Jr., F. S. Friel, J. R. Hoffert, H. E. Moses, W. L. Stevenson.

NETTLETON, ELWOOD THOMAS, Assoc. M., Hamden, Conn. (Elected March 15, 1926.) (Age 39.) Engr. and Sales Mgr., New Haven Trap Rock Co. Refers to C. J. Bennett, E. J. Beugler, A. W. Bushell, C. S. Farnham, C. R. Harte, C. P. Rumpf, W. H. Sharp, C. E. Smith, F. P. Stabell, R. H. Suttie, C. J. Tilden, H. J. Tippet.

O'NEILL, JOHN HENRY, Assoc. M., New Orleans, La. (Elected Assoc. M. March 11, 1929.) (Age 50.) San. Engr., Louisiana State Board of Health. Refers to E. S. Bres, A. T. Dusenbury, G. G. Earl, A. M. Fromherz, A. M. Shaw.

REGESTER, ROBERT THOMAS, Assoc. M., Baltimore, Md. (Elected Junior Dec. 4, 1922; Assoc. M. June 9, 1930.) (Age 35.) Associate Engr. with Whitman, Requardt & Smith, Engrs. Refers to O. Bonney, B. L. Crozier, C. B. Hoover, C. E. Keefer, C. T. Morris, H. S. Morse, G. J. Requardt, F. D. Stewart, F. H. Waring, E. B. Whitman, A. Wolman.

FROM THE GRADE OF JUNIOR

COCHRANE, JOSEPH DERR, Jun., St. Marys, Pa. (Elected Feb. 15, 1937.) (Age 32.) Project Engr. with WPA for Commonwealth of Pennsylvania, Dist. No. 10, in charge of construction in Elk and Cameron Counties.

COOKE, JOSEPH MALCOLM, Jun., Huntington, W.Va. (Elected Oct. 14, 1930.) (Age 32.) Associate Engr., Asst. Chf. of Design Sec., U. S. Engr. Office. Refers to H. A. Levering, T. A. Polansky, C. M. Ross, H. S. Schick, J. H. C. Sprague, W. S. Winn.

GRAY, GEORGE EARLEY, Jun., Oakland, Calif. (Elected Dec. 26, 1934.) (Age 32.) Senior Eng. Aide, California Highway Planning Survey. Refers to F. L. Bixby, H. P. Boardman, E. M. Buckingham, S. M. Hands, J. R. Jahn, R. R. Ribal, C. L. Young.

HARTON, THOMAS GORDON, Jun., Knoxville, Tenn. (Elected Nov. 26, 1934.) (Age 29.) Asst. Engr., TVA. Refers to J. G. Allen, F. H. Conley, N. W. Dougherty, H. L. Fruend, O. Laurgaard, J. P. Laws, G. E. Tomlinson, H. A. Wiersema.

JOHNSON, LEE HARNIE, JR., Jun., University, Miss. (Elected Oct. 14, 1935.) (Age 29.) Acting Dean, School of Eng., Univ. of Mississippi. Refers to S. J. Buchanan, A. Casagrande, J. B. Converse, W. E. Elam, G. M. Fair, A. Haertlein, A. B. Hargis, L. B. Ryon, Jr.

JOHNSON, TOM ROYSE, Jun., Cave Creek, Ariz. (Elected Oct. 26, 1931.) (Age 32.) Associate Engr., U. S. Bureau of Reclamation, Phoenix, being Asst. Field Engr. on construction of Bartlett Dam. Refers to J. A. Fraps, G. T. Grove, W. W. Lane, F. C. Roberts, Jr., G. E. P. Smith.

KINSEL, HARRY LYMAN, Jun., Buffalo, N.Y. (Elected Oct. 1, 1928.) (Age 32.) Asst. Engr., Greeley & Hansen, Hydr. and San. Engrs. Refers to H. M. Freeburn, F. S. Friel, J. K. Giesey, H. E. Moses, A. Richards, J. R. Rumsey, W. L. Stevenson.

MENNE, LEO ERNEST, Jun., West New Brighton, N.Y. (Elected Nov. 10, 1930.) (Age 32.) Draftsman, The Port of New York Authority. Refers to W. J. Barney, H. B. Gates, G. L. Lucas, W. T. McIntosh, R. Smillie.

PANDYA, ANANT HIRALAL, Jun., London, N.W.II, England. (Elected Aug. 15, 1932.) (Age 29.) Chf. Engr. in charge of all design and construction, Diagrid Structures, Ltd. Refers to H. K. Barrows, T. R. Camp, W. M. Fife, G. Gilboy, B. L. Modak. C. M. Spofford, J. B. Wilbur.

PARKIN, GEORGE THOMAS, Jun., Raleigh, N.C. (Elected Oct. 1, 1928.) (Age 32.) Designer, North Carolina State Highway & Public Works Comm. Refers to H. G. Baity, W. G. Geile, T. F. Hickerson, K. N. G. Saurbrey, S. B. Slack, F. C. Snow, R. M. Trimble.

PICKET, DAVID, Jun., New York City (Elected Oct. 14, 1929.) (Age 31.) Pres., Gotham Constr. Corporation. Refers to E. C. Lawrence, J. Loewenstein, C. Mayer, V. Mayper, C. B. Spencer.

REISS, SIDNEY ALEXANDER, Jun., New York City. (Elected Nov. 11, 1929.) (Age 32.) Draftsman, Dept. of Public Works, Bureau of Sewage Disposal & Intercepting Sewers. Refers to A. M. Brosius, E. J. Fort, R. H. Gould, N. I. Kass, W. A. O'Leary, J. W. Van Denburg, F. C. Ziegler.

STIRMAN, HARRY HILL, Jun., Corpus Christi, Tex. (Elected Dec. 14, 1936.) (Age 32.) Engr. for City on utilities, etc. Refers to J. C. Bisset, T. C. Forrest, Jr., C. Manes, E. L. Myers, E. N. Noyes, C. S. Reagan, R. B. Thomas.

TESSITOR, ERNEST, Jun., Sewickley, Pa. (Elected Oct. 14, 1929.) (Age 32.) Designer, Allegheny County Dept. of Works, Pittsburgh, Pa. Refers to H. G. Appel, C. S. Israel, R. S. Quick, S. A. Shubin, M. K. Snyder.

WEST, ARTHUR LOWELL, Jun., Key West, Fla. (Elected Dec. 3, 1926.) (Age 32.) Bridge Engr., Overseas Road & Toll Bridge Dist. Refers to C. B. Cooke, J. H. Dowling, E. Friedman, H. J. Morrison, W. I. Nolen.

The Board of Direction will consider the applications in this list not less than thirty days after date of issue.